March-April 1991

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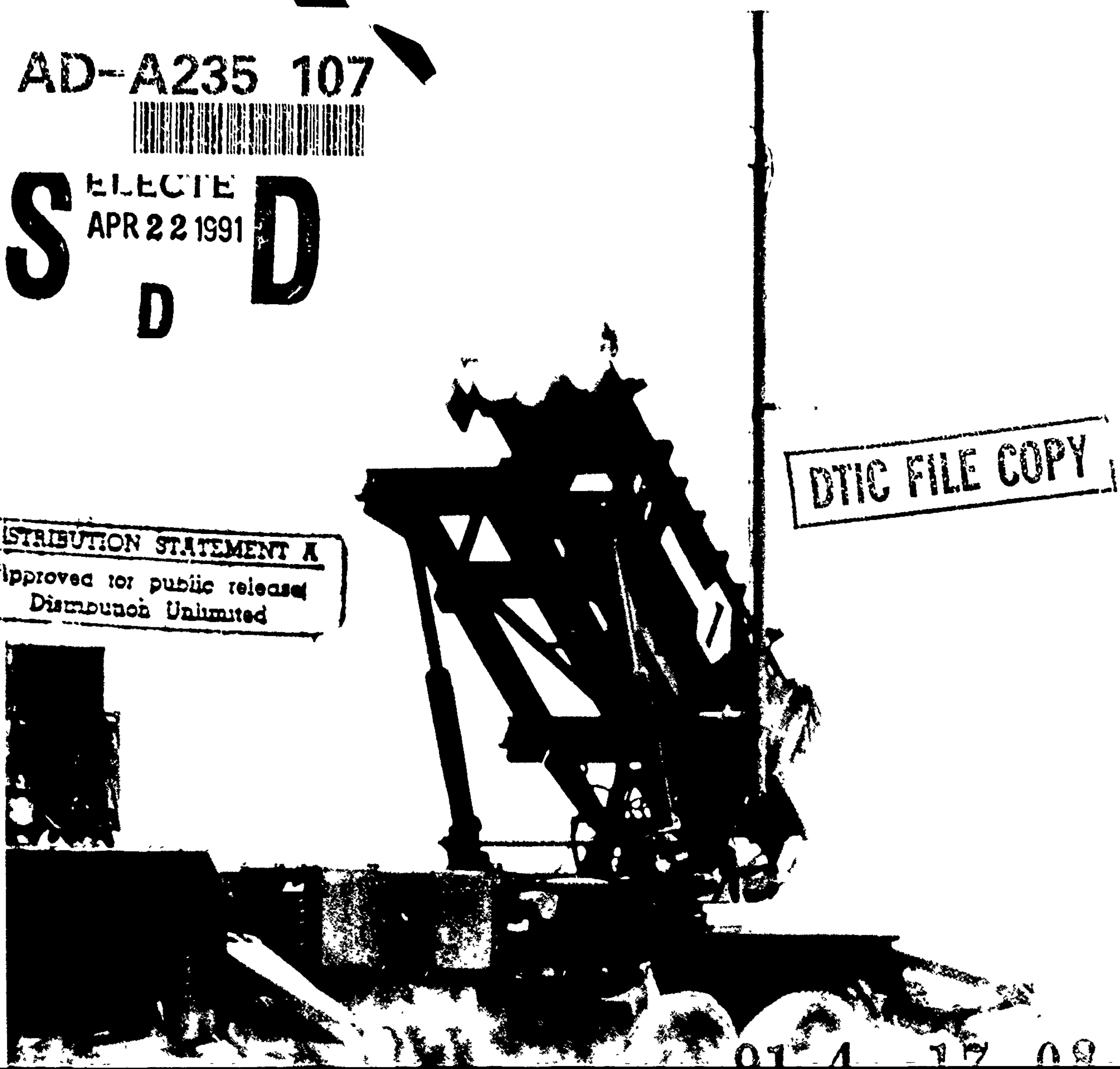
PATRIOT AND DESERT STORM
INTERNATIONAL ARMAMENTS
ADOPTING TQM
ONE—DAY OFFSITE



PROGRAM MANAGER

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Whenever in this publication "man," "men," or their related pronouns appear, either as words or parts of words (other than with obvious reference to named male individuals), they have been used for literary purposes and are meant in their generic sense.

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Cover: Patriot, the combat proved Air Defense System of the Free World, played a vital part in Desert Storm. Story on page 2.

Also

Program Manager is intended to be a vehicle for the transmission of information on policies, trends, events, and current thinking affecting program management and defense systems acquisition.

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PATRIOT

atriot, our cover photo, the cornerstone of the U.S. Army European and Contingency Forces' integrated air defense system, has demonstrated its ability to counter the tactical ballistic missile threat in battle.

The Patriot missile system shown in the desert environment at White Sands Missile Range, N.M., is a multipurpose air defense system, designed to counter aircraft, cruise missiles and tactical ballistic missiles.

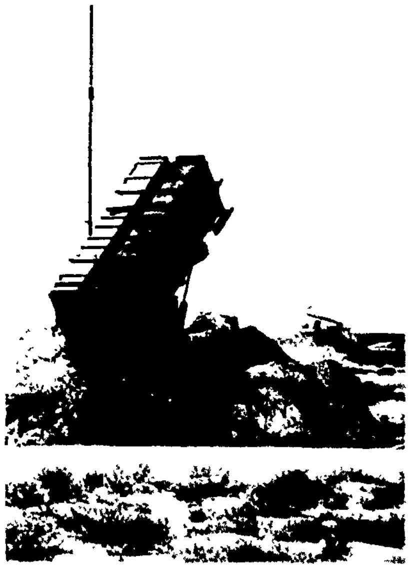
Patriot units can gain Tactical Ballistic Missile (TBM) engagement capability without retrofit of deployed assets. Patriot Anti-Tactical Missile (ATM) capability has successfully demonstrated unparalled performance in its engagements protecting the U.S. and Allied troops of *Operation Desert Storm* as well as national and civilian assets in Israel, Saudi Arabia and Turkey.

In the flight test program before deployment, Patriot scored 15 for 15 successes against real and surrogate TBM targets.

Patriot's operations as part of *Operation Desert Storm* demonstrated a performance capability that meets or exceeds all requirements, making it today a premier air defense system in the Free World.

Patriots Phased Army Radar

One of the war's brightest stars—Patriot—made an impressive appearance by intercepting Iraqi missiles headed for Riyadh, Dhahran and Israel.



Patriot Air Defense System

In test programs, Patriot demonstrated capability to counter the aircraft threat including saturation raids, high-speed targets and highly maneuverable targets in sophisticated electronic counter measures (ECM) environments. Patriot fire power, in terms of rapid rate of fire, fast reaction time and multiple simultaneous engagements meets or exceeds all specified requirements.

Patriot system effectiveness against very advanced ECM threats and the enhanced system survivability resulting from inherent Patriot mobility are very impressive. Added to this is the demonstrated system availability that exceeds requirements and is achieved by a combination of a self-support concept and graceful system degradation.

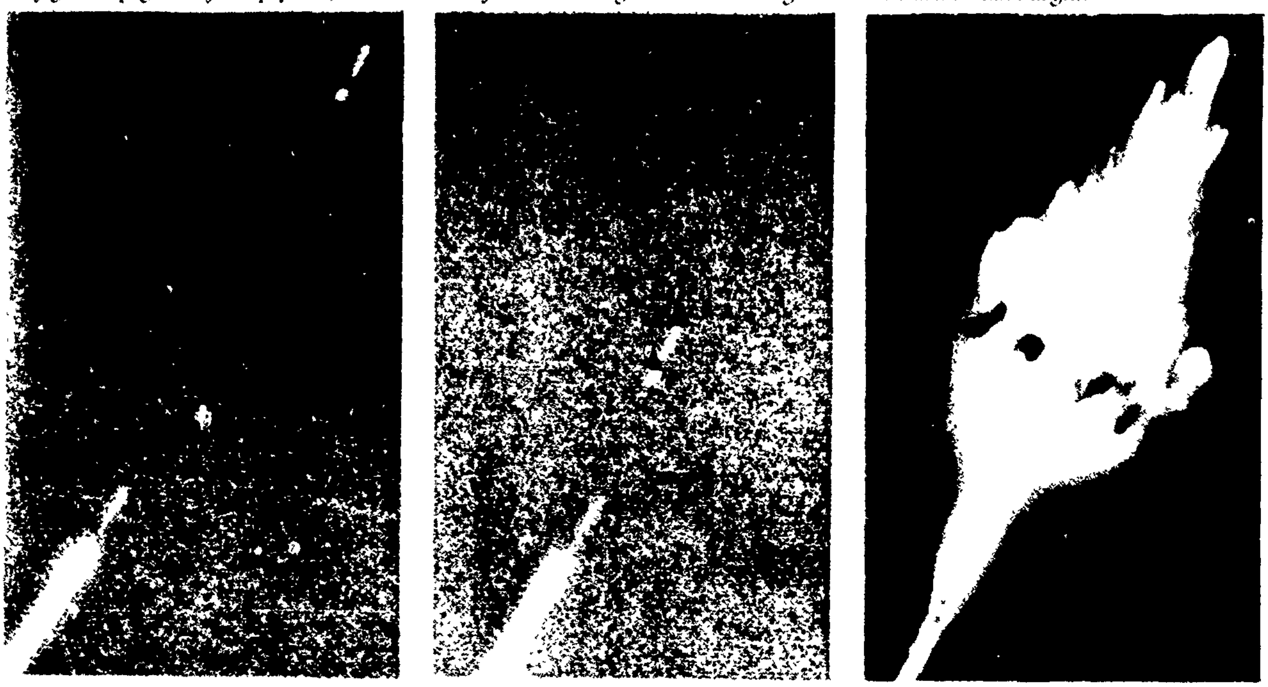
The U.S. Army deployed Patriot to the 32nd Air Defense Command in Europe and the 11th Air Defense Brigade in the United States.

The 32nd is integrated into the NATO Air Defense force structure and the 11th Air Defense Brigades assets support world wide contingency operations such as *Operation Desert Storm*. These units share the air defense burden with Patriot units of our Free World Allies.

The system success in the Middle East and on-going national studies of air defense requirements by NATO and other Allied nations indicate a high interest in Patriot. Both the current, planned and potential growth and modernization of Patriot should assure that it remains the cornerstone for The Free World's tactical air defenses.

– All photos courtesy of Raytheon Co

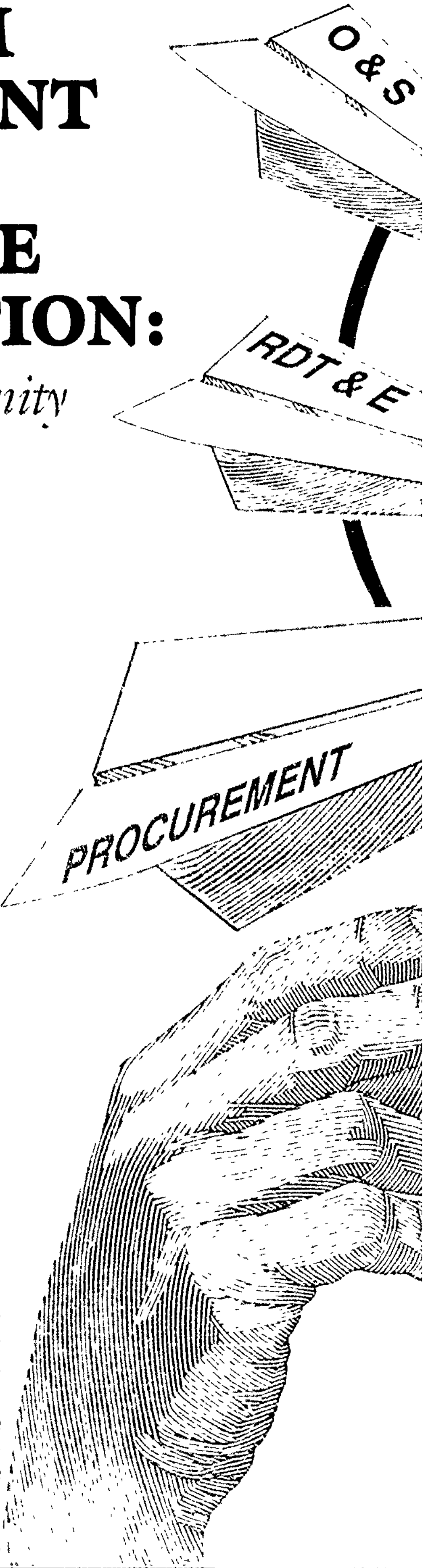
Patriot Anti-Tactical Missile capability successfully demonstrated unparalled performance protecting the U.S. and Allied troops of Operation Desert Storm. In the flight test program before deployment, Patriot scored 15 for 15 successes against real and surrogate Tactical Ballistic Missile targets.



PROGRAM MANAGEMENT AND LIFE-CYCLE COST REDUCTION:

Targets Of Opportunity

Michael N. Beltramo



There is a strong premise that effective budget control requires realistic costing. However, cost analysis and estimation is not synonymous with cost prediction and forecasting. Cost results from scientific and social phenonema interaction during the life of a program. Therefore, even well-founded and realistic cost estimates may contain serious errors because improbable events occurred that were unknown and unknowable when the estimate was made.

Since unforeseeable events will occur that will raise some costs for every program, a strategy must be developed for controlling costs and keeping within the approved budget. Thus, when some cost elements increase unexpectedly, other costs may be reduced to mitigate the problem. The absence of a macro-strategy for controlling the cost of weapon systems inhibits effective program management. The core of such a strategy should be the identification of "targets of opportunity."

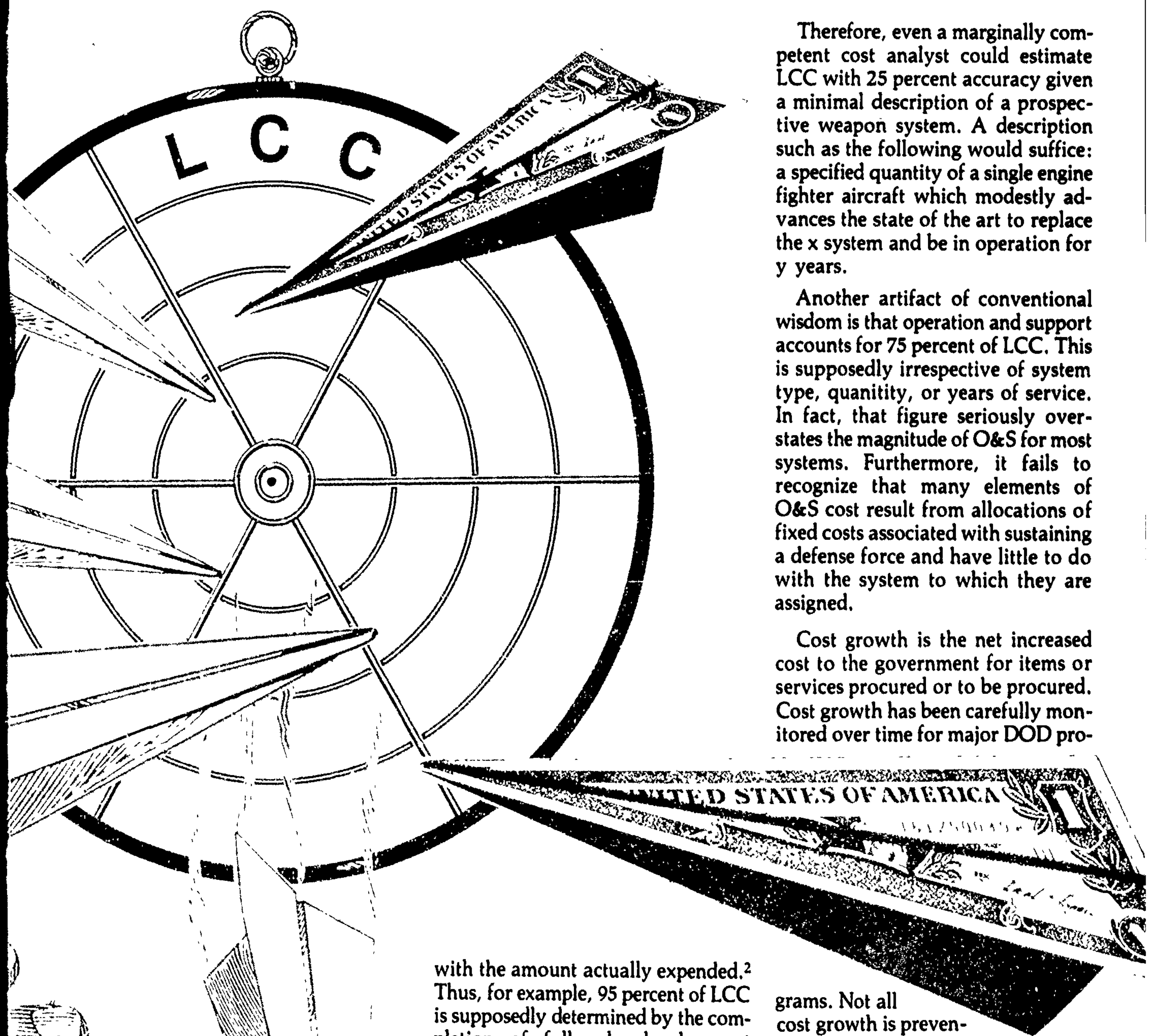
Targets of opportunity are costs subject to control by an effective program manager (PM). It is difficult for a PM to set reasonable cost-reduction objectives because many cost elements and cost drivers are not subject to PM control. But the controllable elements may yield substantial dividends if managed effectively.

This paper considers the various causes of cost growth to identify those an effective program manager could influence. Then, life-cycle cost, (LCC) categories are presented for a hypothetical aircraft system[1] to quantify apporoximately how and where program management might have an impact. This paper seeks to provide a foundation for identifying reasonable targets of opportunity for cost reduction over the life of a program. In the process of building this foundation, it shows some of the precepts of cost analysis to be a hindrance in understanding where leverage may be applied to reduce costs.

Conventional Wisdom and Rules of Thumb As Impediments

Cost analysts sometimes concoct rules of thumb that obfuscate rather than clarify opportunities for cost reduction. For example, it is often stated that most life-cycle costs are committed at an early stage of development and that operation and support dominates life-cycle cost. Furthermore, even well-researched findings related to cost growth are sometimes wrongly construed to imply that cost overruns are unavoidable. These issues are discussed below.

Figure 1 compares the cumulative percentage of LCC presumably committed at each program milestone



with the amount actually expended.[2] Thus, for example, 95 percent of LCC is supposedly determined by the completion of full-scale development (FSD). Yet, only 16 percent of total funds have been spent.

While this may be true, it misses the point. No system really begins with a zero cost baseline. Instead, each phase of its life cycle will require the employment of certain identifiable resources. For example, an aircraft will need engineering and production labor, tooling, raw materials, subcontractor and vendor-supplied components, aircrews and maintenance personnel, fuel, etc. The cost of those resources can be estimated with various degrees of uncertainty during requirement definition, and refined continually thereafter.

Therefore, even a marginally competent cost analyst could estimate LCC with 25 percent accuracy given a minimal description of a prospective weapon system. A description such as the following would suffice: a specified quantity of a single engine fighter aircraft which modestly advances the state of the art to replace the x system and be in operation for y years.

Another artifact of conventional wisdom is that operation and support accounts for 75 percent of LCC. This is supposedly irrespective of system type, quanitity, or years of service. In fact, that figure seriously overstates the magnitude of O&S for most systems. Furthermore, it fails to recognize that many elements of O&S cost result from allocations of fixed costs associated with sustaining a defense force and have little to do with the system to which they are assigned.

Cost growth is the net increased cost to the government for items or services procured or to be procured. Cost growth has been carefully monitored over time for major DOD programs. Not all cost growth is preventable and some cost growth, even though avoidable, may be desirable. For example, technology advances may make it possible to incorporate modifications that result in an overall increase in the effectiveness of the system. Such cost development and production is not always predictable when a weapon system is in development and production during a long period. Historically, economic factors and quantity variances have ac-

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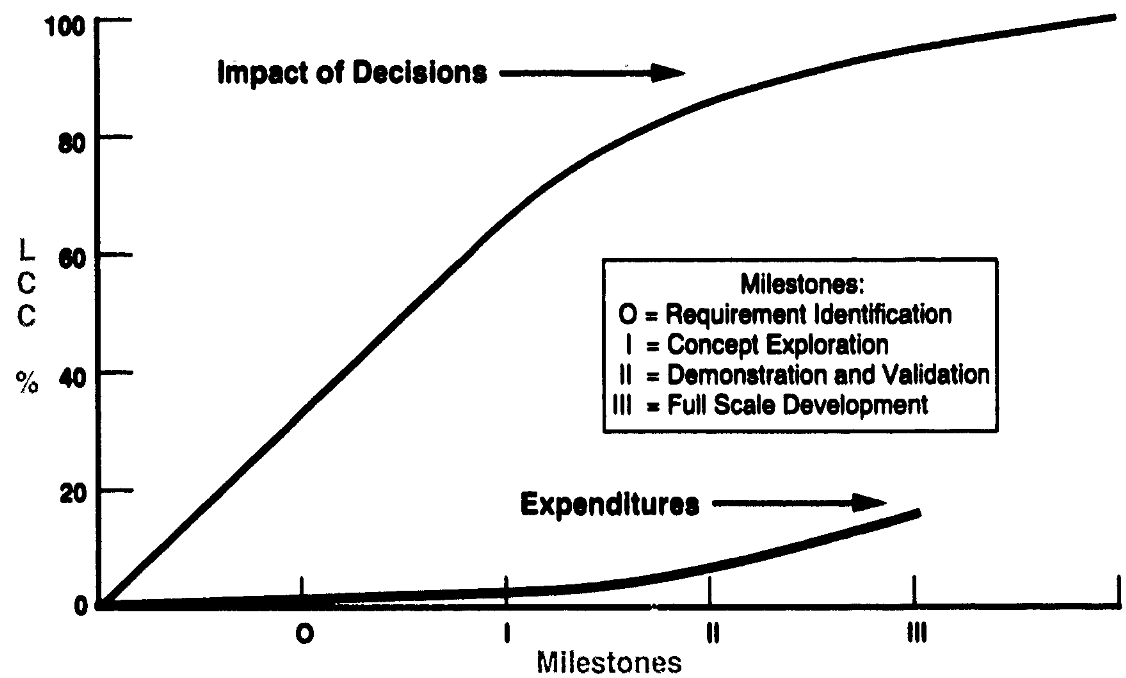
Dr. Beltramo is President of Beltramo and Associates, Los Angeles, a management consulting firm specializing in cost analysis related to competitive strategies, system acquisition policy and program management.

FIGURE 1. FAULTY CONVENTIONAL WISDOM
The Impact of RDT&E Decisions on LCC



Beltramo and Associates

counted for about three quarters of cost growth. A program manager cannot directly influence either of these factors.

All issues discussed above imply that a PM cannot have an important impact on cost. However, program managers can affect cost reduction. The PM must first assess the probable relative and absolute magnitudes of the elements of life-cycle cost. Then, the program manager must define objectives for reducing costs for elements identified as targets of opportunity. Those issues are dealt with below. The following section discusses where a program manager can make a difference. This contrasts with conventional wisdom about most cost elements being beyond a PM's control.

An Assessment of "Manageable Cost Elements"

A rough estimate of LCC for a hypothetical fighter aircraft system shows which cost elements PMs might affect. The following assumptions were made to estimate life-cycle costs (exclusive of government costs):

—Alternative procurement quantities of 140 and 400 aircraft

—Alternative operational lives of 15 and 20 years

—Procurement costs were estimated by applying the Beltramo and Associates Fighter Aircraft Cost Estimating Model to hypothetical light weight fighter subsystem weights

—Munitions, armament, and support equipment were not included under procurement

—Initial spares were estimated as 25 percent of flyaway cost

—O&S costs were based on F-16 squadrons of 24 primary alert aircraft (PAA), each with 300 annual flying hours. They were estimated using the USAF CORE Model.

The estimates are presented in Table 1. The estimates provide a rough approximation of the absolute and relative magnitudes of the various LCC elements. They lack much of the detail and rigor that would be desirable for other purposes. For example, RDT&E and nonrecurring costs are constant for both alternative quantities. However, in reality they would probably be greater for 400 units due to additional facilitization and tooling required to support a higher production rate.

Table 1 shows that acquisition (i.e., RDT&E, nonrecurring, and procurement) costs tend to dominate for low quantities and shorter periods of operation while O&S costs tend to dominate far higher quantities and longer periods of operation. This is logical as O&S costs would be negligible for a system that is never deployed and relative acquisition costs would be minimized for a system with and extremely long life. Consequently, operational plans should drive a PM's cost reduction strategy. If O&S costs are low even under worst case asumptions, an added investment to reduce them further may not pay off. The remainder of this paper considers costs which might be directly affected by the PM as well as the magnitude of the impact he could make.

Actions taken by a program manager could affect from 85.6 to 91.2 percent of LCC for the cases

TABLE 1. LIFE-CYCLE COST COMPARISON OF LIGHT WEIGHT FIGHTER AIRCRAFT ALTERNATIVES

	140 Aircraft				400 Aircraft			
	15 Yr. Life		20 Yr. Life		15 Yr. Life		20 Yr. Life	
	$	%	$	%	$	%	$	%
RDT&E and Nonrecurring	1,796	32.4%	1,796	29.0%	1,796	15.5%	1,796	13.2%
Procurement	1,802	32.5%	1,802	29.1%	4,000	34.4%	4,000	29.5%
Airframe	952	17.2%	952	15.4%	2,040	17.5%	2,040	15.0%
Engines	252	4.5%	252	4.1%	600	5.2%	600	4.4%
Avionics	238	4.3%	238	3.8%	560	4.8%	560	4.1%
Initial Spares	360	6.5%	360	5.8%	800	6.9%	800	5.9%
Operations and Support	1,942	35.1%	2,591	41.9%	5,828	50.1%	7,772	57.3%
Unit Mission Personnel	539	9.7%	718	11.6%	1,616	13.9%	2,155	15.9%
Aircrew	62	1.1%	83	1.3%	187	1.6%	249	1.8%
Aircraft Maintenance	394	7.1%	525	8.5%	1,181	10.2%	1,575	11.6%
Other	83	1.5%	110	1.8%	248	2.1%	331	2.4%
Unit Level Consumption	385	6.9%	513	8.3%	1,154	9.9%	1,539	11.3%
POL	272	4.9%	362	5.8%	815	7.0%	1,087	8.0%
AC Maint Material	113	2.0%	151	2.4%	339	2.9%	452	3.3%
Depot Maintenance	356	6.4%	475	7.7%	1,069	9.2%	1,425	10.5%
Sustaining Investment	238	4.3%	318	5.1%	714	6.1%	952	7.0%
Rep Spares	183	3.3%	244	3.9%	549	4.7%	732	5.4%
Support Equipment	48	0.9%	65	1.1%	145	1.2%	194	1.4%
Modification Kits	7	0.1%	9	0.1%	20	0.2%	26	0.2%
Installation Support Pers	91	1.6%	122	2.0%	274	2.4%	365	2.7%
Base Opr Support	74	1.3%	99	1.6%	223	1.9%	298	2.2%
Real Prop Maint	10	0.2%	13	0.2%	29	0.2%	38	0.3%
Medical	7	0.1%	10	0.2%	22	0.2%	29	0.2%
Indirect Pers Support	77	1.4%	103	1.7%	232	2.0%	310	2.3%
Misc O&M Support	45	0.8%	60	1.0%	136	1.2%	181	1.3%
Medical Support	9	0.2%	12	0.2%	27	0.2%	37	0.3%
PCS	23	0.4%	31	0.5%	69	0.6%	92	0.7%
Pers Acq and Trng	256	4.6%	342	5.5%	769	6.6%	1,026	7.6%
Acq (Inc. Basic Tng)	198	3.6%	265	4.3%	595	5.1%	794	5.9%
Specialty Training	58	1.0%	77	1.2%	174	1.5%	232	1.7%
Total LCC	5,540	100.0%	6,189	100.0%	11,624	100.0%	13,568	100.0%

shown in Table 1. Specifically, a PM could affect all cost elements except O&S costs related to aircrews, installation support personnel, indirect personnel support, and personnel acquisition and training. Although none of the affected costs could be eliminated, they might be reduced somewhat. Of course, better decisions could lead to more savings while poor strategies could increase costs. Each LCC category and some key cost elements are considered below to indicate the potential impact of an effective PM.

RDT&E and Nonrecurring Costs

Funds for RDT&E and nonrecurring investments can provide a good return during procurement and operation and support. Therefore, the motivation of PMs during this phase should be to make wise tradeoffs. This might result in higher short-term costs to achieve long-term saving.

The RDT&E costs are perhaps more subject to program manager control than any other LCC category. This is because planned performance specifications, operational capabilities and maintenance objectives may be reduced to stay within budget. Also the number of prototype aircraft can be reduced and testing can be limited to minimize costs.

It would be difficult to prove a high correlation between cost and operational capabilities and reliability and maintainability. But "-ility" improvements are rarely obtained for free. Therefore, program management should attempt to get the most from available RDT&E funds and not attempt to achieve false savings by cutting corners.

The division between nonrecurring investment and RDT&E i somewhat arbitary because both categories include one-time costs incurred in preparation for production. The magnitude of the nonrecurring investment depends chiefly on the aircraft design, number of prototypes, length and complexity of the testing program, and tooling for the target production rate.

Like RDT&E, nonrecurring investment may also represent short-term costs to achieve greater long-term savings (e.g., more costly tooling may permit beneficial capital/labor tradeoffs). Thus, the program manager should exempt much of 13 to 32 percent of LCC, represented by the RDT&E and nonrecurring investment categories Table 1, from cost-cutting efforts. The PM should instead concentrate on maximizing the value obtain from available resources.

Procurement

Aircraft procurement accounts for about 29 to 34 percent of LCC in the examples shown in Table 1. This should be minimized within the constraint of obtaining an aircraft that meets design specifications and operational requirements. Of course, the potential for cost reduction depends upon the accuracy and basis of the estimate incorporated into the budget. For example, a parametric cost estimate for an advanced technology airframe prepared using models based upon conventional airframe technologies might offer greater room for reduction than engineering cost build-up based upon well-known components and processes.

Newer aircraft exhibit reduced maintenance man-hours compared to aircraft from the previous generation.

Program managers may implement policies that encourage and enable the contractor to be a more efficient producer. For example, the PM may act to assure an efficient production rate to avoid excess capacity and associated higher overhead costs. Multiyear contracting may be implemented when there is no risk of program cancellation and when a long-term commitment will result in lower costs. These result from taking advantage of volume purchases and avoiding production interruptions. Also, the judicious implementation of engineering changes during production can reduce costs.

Since the reduction of procurement costs is sensitive to the estimating methodology upon which the budget is derived, quanitfying the potential for cost reduction is highly speculative. However, extensive data on competitive programs indicate that price can often be reduced significantly. Therefore, 20 percent reduction of procurement costs may be a reasonable goal. That would reduce LCC by about 6 to 8 percent. Of course, the uncertainty for achieving this savings would be moderate to high.

Operation and Support

The PM might affect the logistics support cost (LSC) component of O&S.[3] Elements of LSC represent about 26 to 43 percent of LCC in the examples provided in Table 1. The LSC is driven by reliability and maintainability. For example, the program manager can affect R&M by contract incentives and warranty provisions.

Newer aircraft exhibit substantially reduced maintenance man hours compared to aircraft from the previous generation. For example, USAF logistics support cost factors indicate that the annual cost for an F-16 squadron is about 30 percent lower than for an F-4E squadron. Hence, an LSC savings of as much as 25 percent compared with current fighter aircraft might be a reasonable goal for a PM. That would reduce LCC by about 6 to 10 percent.

Conclusion

A preoccupation with uncontrollable cost elements and factors which cause cost growth and misguided conventional wisdom have averted attention from real cost reduction opportunities. Lower costs may be achieved if targets of opportunity are identified and pursued at an early stage in a program. An effective program manager can have an important impact on reducing program cost. Potential cost savings for the light-weight fighter example are summarized in Table 2 by LCC category. They were derived by applying the gross assumptions discussed above to the cost estimates presented in Table 1. A program manager may affect cost elements equal to between 86 to 91 percent of life-cycle cost in this example. An LCC reduction of nearly 17 percent represents a significant potential savings and may not be an unreasonable goal.

Although it is impossible to measure the actual effect of a PM on cost, there is little doubt that it can be considerable. This paper examined how an effective program manager can reduce cost. Conversely, poor program management decisions can increase cost, reduce performance and delay schedules. Therefore, it is crucial to adopt strategies that will lower LCC as well as strategies for

TABLE 2. SUMMARY OF LCC TARGETS OF OPPORTUNITY

		140 Aircraft				400 Aircraft			
		15 Yr. Life		20 Yr. Life		15 Yr. Life		20 Yr. Life	
	% Sav.	Est. Cost	Pot. Sav.	Est. Cost	Pot. Sav.	Est. Cost	Pot. Sav.	Est. Cost	Pot. Sav.
RDT&E and Nonrecurring	0	1,796	0	1,796	0	1,796	0	1,796	0
Procurement	20	1,802	360	1,802	360	4,000	800	4,000	800
Operations & Support									
LSC	25	1,456	364	1,941	485	4,366	1,092	5,822	1,456
Ops. & Ind. Supt.	NA	486	0	650	0	1,462	0	1,950	0
Total LCC		5,540		6,189		11,624		13,568	
Total PM Cost Impact		5,054		5,539		10,162		11,618	
Potential PM Savings			724		846		1,892		2,256
PM Impact/LCC		91.2%		89.5%		87.4%		85.6%	
Potential Savings		13.1%		13.7%		16.3%		16.6%	

meeting technical, performance and schedule goals.

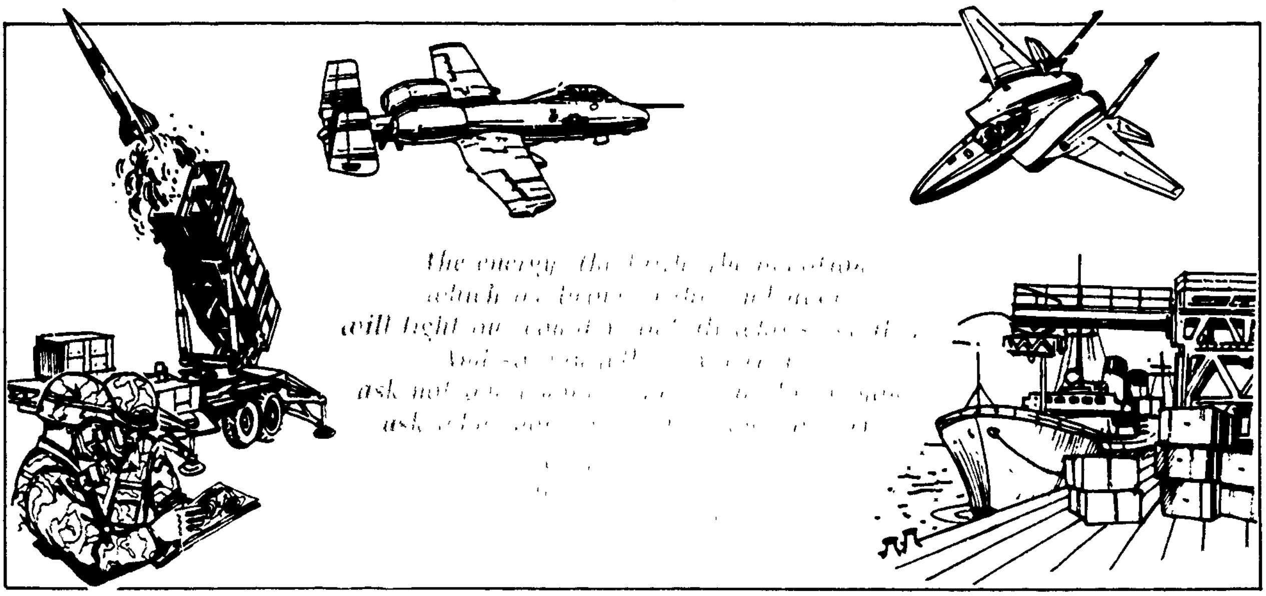
The uncertainties inherent in even the best cost analyses can lead to budget overruns. Higher costs in some areas may be offset somewhat by identifying cost elements and cost drivers that may be responsive to program management initiatives and implementing strategies for controlling them.

Endnotes

1. Costs shown in the tables were prepared for an analysis completed in the early 1980s. Therefore, the absolute amounts are no longer valid and even relative amounts may have changed. But they are still useful for the intended purpose.

2. A source for this figure is the *Navy Program Manager's Guide*. It offers no calculations to support its assertions but, instead, an editor of that publication noted that percentages shown "represent expert opinion."

3. These include all O&S elements except aircrews, installation support personnel, indirect personnel support, and personnel acquisition and training.



THE "HITHER AND YAWN (YON)" OF STATEMENT OF WORK PREPARATION

A Trip Through the Process With the Fictitious B-3

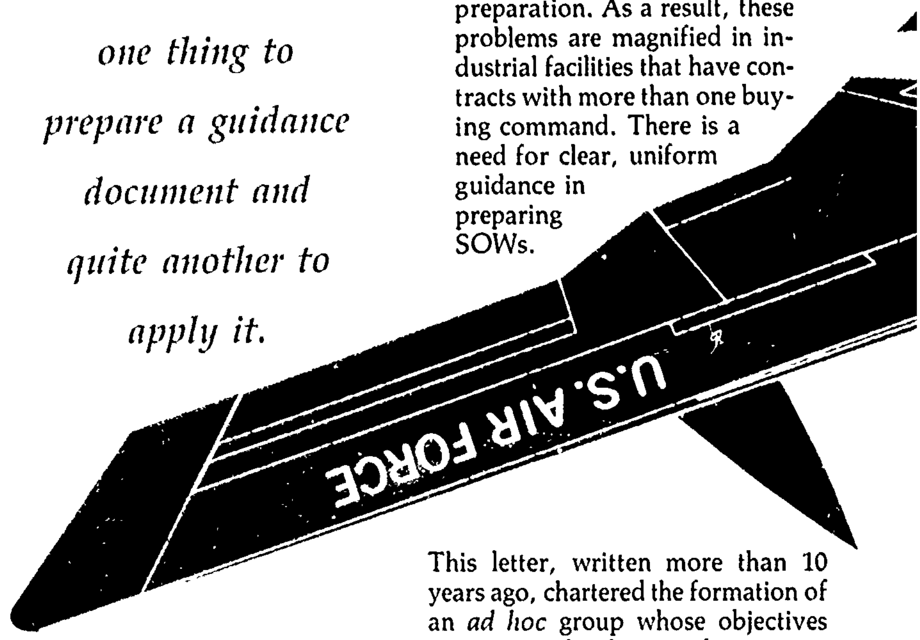
Mr. Richard A. Andrews
Captain R. Terry Adler, USAF

As you may remember, our first article on statements of work (SOW) appeared in the May-June 1990 issue of this journal. It was entitled "Is Your SOW a Statement of Work or a Source of Woe?" and was aimed at educating you on the purpose of a SOW, history of SOW preparation guidance, mechanics and basic results of a SOW Survey of more than 2,200 Air Force System Command (AFSC) program managers, interrelationship of the SOW to the solicitation, and the SOW review process.

We have received numerous calls, letters, and face-to-face comments on the timeliness of the article. The most widely asked question has been: "When will the follow-up article be available, as advertised?" Here it is.

After restating the problem, we'll explain the format, purpose and content of the three major SOW sections, identify and describe the five types of SOWs, review do's and don'ts of SOW preparation, highlight sources of SOW education or training, and conclude with recommendations for improving the SOW development process. Our sources have been, and will continue to be, MIL-HDBK-245B, our program manager survey, government policies, our own experiences, logic, and common sense.

We realize that it's one thing to prepare a guidance document and quite another to apply it.



Restatement of Problem

Perhaps the most point-blank statement of the problem we face in SOW development, and the resultant compelling need for improvement, can be found in an August 1980 letter from the Office of the Under Secretary of Defense which said in part:

> Problems exist with SOWs as presently written. They have become overly complex, lack clarity and vary in content. Different services use different guidance documents for their preparation. As a result, these problems are magnified in industrial facilities that have contracts with more than one buying command. There is a need for clear, uniform guidance in preparing SOWs.

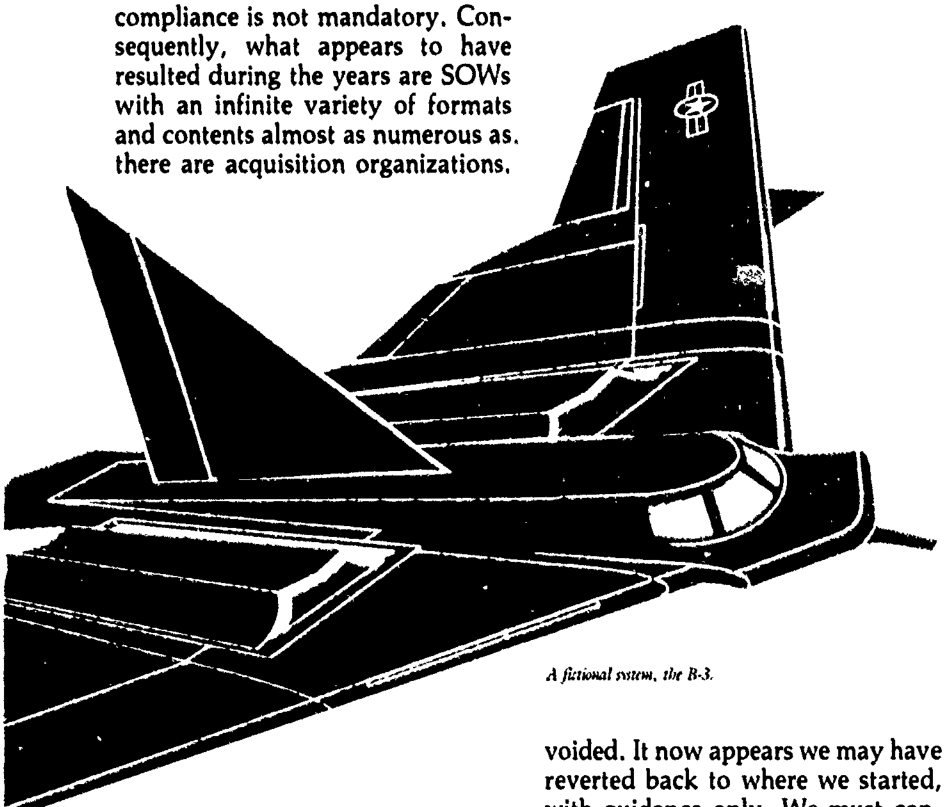
This letter, written more than 10 years ago, chartered the formation of an *ad hoc* group whose objectives were to "...develop a military standard or handbook which: provides a broader base of proposers resulting from complete, clear requirements and risk identification; reduces delays in source selection by reducing or eliminating the need to go back to

Mr. Andrews is an assistant professor of acquisition logistics, School of Systems and Logistics, Air Force Institute of Technology, Wright-Patterson AFB, Ohio.

Captain Adler is the SRAM II Warhead integration program manager, SRAM II System Program Office, Aeronautical Systems Division, Wright-Patterson AFB, Ohio.

proposers for additional information on qualification, etc; minimizes the contractors building in contingency allowances resulting from unclear requirements; enhances the quality and inventiveness of proposals; reduces proposal size, cost, and preparation time by the government."

From what we can determine, the result of the committee was MIL-HDBK-245B. Unfortunately, as a handbook, it only serves as "guidance" just as the original letter optionally tasked the committee to develop. The overwhelming interpretation of the term "guidance document" has been taken to mean that compliance is not mandatory. Consequently, what appears to have resulted during the years are SOWs with an infinite variety of formats and contents almost as numerous as there are acquisition organizations.



A fictional system, the B-3.

As trivial as it may sound, the word "implement" was never used in the OSD letter. We realize that it's one thing to prepare a guidance document and quite another to apply it. Our experiences in academia have shown that a surprisingly large percentage of acquisition personnel are not aware that MIL-HDBK-245B exists, let alone do they use it in SOW preparation.

Before we progress too far, one correction must be made. In our previous article we stated that "Current Air Force SOW preparation policy is contained in AFSCR 800-6...." That was in error. It should have said "Air Force Systems Command SOW preparation policy is contained in AFSCR 800-6." The difference is significant. In the former, the entire Air Force would have been required to comply with the MIL-HDBK-245B procedures, while in the latter, only Air Force Systems Command organizations would be accountable. Subsequently, we have discovered that our mistake has been rendered academic. The AFSCR 800-6 has been rescinded. What we saw as a first real step toward true SOW standardization has been voided. It now appears we may have reverted back to where we started, with guidance only. We must conclude that as long as there is no standardized requirement for SOW preparation, we will continue to prepare and issue SOWs that are "...overly complex, lack clarity and vary in content."

SOW Format

In addition to a title page, the basic SOW should consist of three sections: Scope, Applicable Documents, and Requirements. If the SOW is more than five pages in length it should have a table of contents. Deviation from the standard format may be made to accommodate overriding program needs.

Section 1: Scope

This SOW section contains a description of what the SOW covers; i.e., section 1 in a full-scale development SOW would specify that this SOW is for the design, development and testing of the system. Where appropriate, it should include a summary background of the problem and, depending on SOW type, a system description. Separate levels of indenture in this section may be necessary to support complex acquisitions, especially for background information. Tasking the contractor to perform work, or the discussion of data requirements, or data deliverable products should never be included in this section.

Section 2: Applicable Documents

Section 2 is used to list all applicable documents called out by specific reference in section 3 of the SOW. The actual extent of applicability of a document referenced in section 2 will be specified in section 3 by identifying only those portions of the document needed to solicit the effort required. The referenced document must be identified by number and title and it would be beneficial to include the date of the publication. The listing of an applicable document in section 2 without having it specifically mentioned in section 3 does not create an impacting condition on the contractor. Never use DOD and departmental instructions (government regulations and manuals) in a SOW, except in Type V SOWs. They were devised to manage and control government in-house activities, not a contractor. Only contractually applicable tailored standards, specifications and so forth should be used in a SOW. Guidance documents may be conveyed to the contractor in the Instructions to Offeror/Bidder (section L) of the solicitation.

Section 3: Requirements

This is the critical section of the SOW. Here is where we define the

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EDITOR'S NOTE:

Because of a resounding response to their first article in the May-June 1990 Program Manager, *the authors have written more on SOW development.*

work or task efforts to be performed by the contractor. The arrangement of section 3 must be systematic, logical and in accordance with the work-breakdown structure specified in MIL-STD-881. It is vital that each contractor tasking contain the proper reference to "shall," "should" or "may" to indicate clearly whether a tasking is "mandatory," "desirable," or "alternative." The term "will" may be used to express a declaration of purpose or futurity; i.e., common support equipment for in-factory use will be provided to the contractor as government furnished equipment. Where practical, taskings should be written in a chronological order and in a manner and sequence to facilitate administration of the contract.

Types of Sows

According to MIL-HDBK-245B there are five types of SOWs. They are Concept Exploration, Demonstration and Validation, Full-Scale Development, Production and Deployment, and Nonpersonal Services. Though the names of the phases in the acquisition process may change, the fundamental activities that occur in a given phase remain fairly constant. Although the SOW is primarily viewed as a document that defines a contractor's responsibilities, the SOW preparation procedures should be applied independent of who will perform the effort, even if that work is done by another government organization.

TYPE I: Concept Exploration (CE)

The objective of the CE phase is to define and identify alternative system design concepts that may satisfy mission needs. Because of our limited ability to accurately identify and define the product desired, a Type I SOW is usually restricted to an expression of objections or goals. A Type I is used when it is necessary to define the technical requirements in the SOW because the efforts are inevitably stated in terms of objectives or goals rather than quantitative or qualitative tasks; like those included in a specification. In fact, typical programs do not have a system specification at this point in the acquisition cycle. For this reason, you will likely see specification like requirements in the concept exploration SOW. Likewise, data or technical reports resulting from the work tasks defined in a Type I are discussed and ordered within the SOW. The AFR 310-1, Management of Contractor Data, specifically states that provisions of the regulation do not apply to "Research or development contracts when reports are the only deliverable item under the contract." Therefore, a separate contract data requirement list (CDRL) normally would not be required on a CE contract.

Section 1 of a Type I SOW routinely will contain a statement of the problem, a short functional description of the overall system, and a graphic display of major milestones of the program in time sequence. Section 3 generally will provide a summation of known alternatives for development; a time phasing of studies, if appropriate; data reporting requirements; and, where necessary, an identification of subsystem relationships. We must be cautious that we do not write a CE SOW where the description of the work effort is so vague that it renders the contract difficult to enforce or where it is so stringent that it stifles contractor flexibility and innovativeness.

TYPE II: Demonstration and Validation (D&V)

A Type II SOW will be more descriptive of contractor work efforts and more conclusive in identifying goals and objectives. It is used to refine and define to a lower level the details of system performance and support. Essentially, the D&V phase SOW is limited in scope to efforts required to conduct the proofing or prototyping (if deemed appropriate), assess results of proofing or prototyping, and define system performance requirements to the end-item level. Work efforts in a Type II SOW would include system engineering, possible construction of hardware, analysis of design and cost trade-offs, risk assessment and program planning. To ease transition into the full-scale development phase (FSD), the D&V SOW should be correlated to selected elements of the FSD preliminary work breakdown structure elements that are applicable.

Normally, a D&V contract will require delivery of defense material, so it is necessary that a separate CDRL for data ordering be used. Per AFR 310-1, the SOW still must stipulate the work effort that would generate the by-product of data. However, the SOW does not directly call out the preparation or delivery of the data, except in a Type I SOW. The resulting data by-products from a typical Type II SOW would generally include systems engineering and program management plans, development specifications, logistics support analysis record, engineering drawings (level 1 or equivalent), cost reports, etc.

TYPE III: Full-Scale Development (FSD)

A Type III SOW is prepared when a specification is used to define the qualitative and quantitative technical requirements for performance and support. During this phase, the contractor performs design, development, test and evaluation of the system based on the functional and allocated baselines that are products of the system definition in the concept exploration and demonstration and validation phases. The system includes the prime mission defense material and all items necessary for its support. Some additional SOW taskings would include a continuation of design and cost trade-offs, design and management reviews, risk assessment, and the LSA process; implementation of quality and configuration management programs; planning of test support; and production planning. The intended output of the FSD phase is a configured system and the documentation needed to produce that system.

When management data are expected to result from a task, the description of the work effort should be detailed enough to result in generating the desired information without having to rely on the data item description as the forcing function for data creation. The procedures for FSD data identification and contractual acquisition are accomplished in the same manner as was specified for the D&V phase.

TYPE IV: Production and Deployment

The Type IV SOW is used to culminate end-efforts of the research and development phases by supporting production and ultimate deployment of the system. In this phase, the contract specification is converted into a military specification to control the "manufacture to" design and the manufacturing processes. All necessary tasks deferred from earlier phases will be readdressed and actions initiated for their completion. In a large percentage of cases, these deferrals involve support resources; such as, provisioning, technical publications, support equipment and training. Most support deferrals to the production phase are usually, but not exclusively, limited to depot-level capabilities. Many taskings included in the production SOW are logical and necessary continuations of efforts begun in the FSD phases or earlier. Data identification and acquisition process in the production phase are done in the same manner used in the D&V and FSD phases.

TYPE V: Nonpersonal Services (NPS)

The Type V SOW is used when the need for contractor support is identified independent of the actual development and procurement of the defense material item. The NPS contracts can occur during any phase of the acquisition cycle. There are two criteria that must be satisfied and adhered to when contemplating their use. First, the SOW must explicitly establish what work is to be done and require the delivery of a product other than periodic progress reports. Second, the contractor's employees must not be supervised by the government during execution of the work and production of the product.

Unlike previous SOWs, Type I through IV, departmental instructions and other policy documents may be referenced or invoked in the SOW to define to an NPS contractor a method of work performance. Departmental policies and procedures used to control similar in-house work efforts must be thoroughly understood by the SOW writer and those rules defined for the contractor's guidance.

Progress reports are not considered the deliverable product in an NPS contract. They are a normal part of the contract management process. When used, the SOW should specify the format and arrangement of the reports to include work accomplished, problems encountered, problems solved, cost information, funds expended and frequency of report delivery. A CDRL may be used for ordering other data items as needed.

The Do's and Don'ts Of SOW Preparation

Perhaps the single most important factor in SOW preparation activities is keeping to a systems engineering approach in organizing, developing and writing individual work statements. Remember, the SOW is the tasking document used:

—By the government to delineate program requirements and to integrate these requirements into a single-source document.

—By the contractor to price out the scope of the effort, set objectives, agree to provide work as stated in the negotiated SOW, and "to manage" their work according to the SOW language.

—By legal authorities to vindicate either the government or the contractor regarding contractual disputes and obligations.

The magnitude of these objectives cannot be overstated. The SOW is the SPO document used to measure follow-on schedules, deliverables and contractual performance. That's what it was intended to be and that's what history has repeatedly proved. The MIL-HDBK-245B states the importance of the SOW:

> After the contractor has been selected and the contract awarded, the SOW becomes the standard for measuring the contractor's effectiveness. As the effort progresses, the DOD and the contractor will constantly refer to the SOW to determine their rights and obligations with regard to contractor response. When a question arises concerning an apparent increase in the scope of work to be performed, the SOW is the baseline document which must be used to resolve this question. Language in the SOW defining the scope of outer limits of the contractor's effort is of critical importance at this time. If the limits were poorly established, it will be difficult to determine if or when there has been an increase in scope, with the result that effective negotiations on cost and schedule will be impaired, if not impossible.

How should program managers write an effective SOW? By necessity, the program manager must strive to prepare SOWs that are clear concise and unambiguous. We found that proper SOW development involves 5 fundamental steps:

—Setting government and contractor objectives (acquisition strategy)

—Organizing and tailoring SOW structure (MIL-STD-881A)

—Writing SOW tasks (MIL-HDBK-245B)

—Negotiating SOW content with the contractor(s)

—Changing SOW requirements as the program evolves (contract change proposals, engineering change proposals).

Each step is important but we focused emphasis on 2 and 3. We feel these are the "corporate" weaknesses in Air Force SOW preparation.

The first "do" for organizing and tailoring the SOW structure concerns composition of the SOW preparation team. Because of the SOW criticality, the individual selected to lead the SOW preparation effort should be experienced in systems acquisition and SOW development. This is not the time to be looking for the newest or lowest-ranking person in the organization. Apparently one program manager used our survey to frustration on this exact matter:

"The newest lieutenant gets to do the next SOW (Air Force Rule #212)." The same thought was echoed by many program managers responding to the survey.

Once a leader is identified, the team should be formed. The team should consist of, at a minimum, a functional expert from each distinct discipline that will have taskings in the SOW. The initial team meeting should be directed at ensuring complete team understanding of the program objectives, acquisition strategies, user requirements and areas of responsibilities. All this should be done before the first SOW words are written. Why is this so important?

Well, on frequent occasions in our SOW review consulting efforts, we find SOWs where tasks are redundant, obsolete or inconsistent. For instance, does it make sense to tell a contractor how to package, handle and transport an end-item deliverable in the SOW, and in the contract schedule, and in a data item description, and in the specification? No!

To eliminate possible task conflicts, a contractor should only be told in a contract one time to perform a specific effort. Multiple tasking statements lead to a waste of contractor time and government dollars, and create loopholes. One survey respondent so stated:

> A competent team needs to be created and committed to producing a quality SOW. Experience is not necessarily best. I've had team members submit SOW tasks without checking to see if the tasks apply. Common sense (although not very common) is important. For example, I had an "experienced" team member insist on adding a task to have the contractor write a report. I asked why not have the contractor revise the existing report instead of writing a new one (this was an ongoing effort). My biggest problems have been getting everyone to agree on a tailored SOW (tailored to fit the requirements). They all want to add their standard requirements even if it doesn't fit—"better to have too much than not enough" attitude.

The team approach is necessary because it highlights one of the most important ingredients of the systems engineering process—people. It's the people who make the program work on the government and contractor sides. Why not use them effectively?

A valuable tool for development and management of SOW requirements is the work breakdown structure (WBS) as described in MIL-STD-881A. We found the WBS to be an excellent initial starting point for organizing and tailoring the SOW and identifying interfaces involved in program management. Unfortunately, today, the WBS is usually associated with the cost-estimating field and given the stigma of being a "bean counter's" responsibility. This is a blatant misuse of the WBS. The WBS originally was developed by systems engineers *for* systems engineers. Its format is intended to capture years of experience in weapon systems acquisition, yet allow enough flexibility for a SOW to be tailored to fit individual program needs. Ignoring the WBS and what it can do for you may be putting the program at risk. Program managers were asked to respond to the following statement in our earlier survey: "One of the first steps in developing and writing the SOW is to use the program's current Work Breakdown Structure, MIL-STD-881A, for outlining what needs to be done."

We were surprised at the result. Of the 1,088 responses, 54 percent agreed that the WBS was a valuable tool, while 41 percent did not. Maybe, at least in part, the high level of disagreement could stem from a lack of previous education regarding the WBS. One example of the misunderstanding existing in the WBS use can be seen in remarks of one survey respondent. "Shoehorning every SOW into the MIL-STD-881A WBS categories is counterproductive. It promotes SOW preparation as a rote 'cut-and-paste' exercise with too little creativity. As a result, unnecessarily rigid task procedures tend to be called out and too much data is asked for."

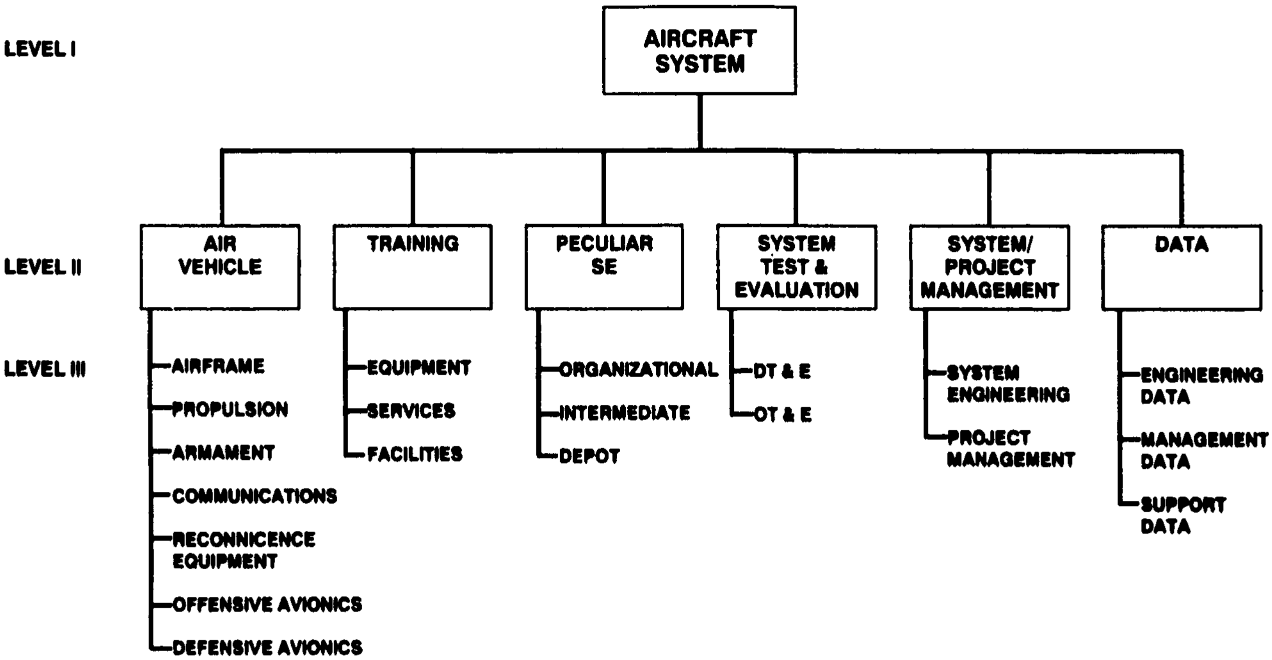
The WBS format was never intended to be enforced verbatim, but used as a starting point for future tailoring by program managers. Rigid task procedures and too much data are issues needing to be resolved within the SPO before solicitation release or contract award. The key point is that the WBS does not drive our requirements. *We do*. It merely provides the framework. The following example shows how the WBS can be used to aid in SOW formatting.

Let's take a fictitious system, the B-3 Bomber. First, the upper three levels of the WBS are extracted from the appropriate appendix in MIL-STD-881A. In our case, Appendix A, or Aircraft WBS (Figure 1). This would be the starting point for tailoring program requirements. To organize our program requirements, we must have an established acquisition strategy. The strategy should address such things as level of competition, estimate of contract value, type of contract, time phasing and program incentives.

To tailor the WBS properly, the SOW preparer must understand this strategy. As for our fictional B-3 Bomber system, we could have the propulsion subsystem acquired by an engine SPO as is done at the Aeronautical Systems Division, Wright-Patterson AFB, Ohio. The acquisition strategy may have other selected subsystems broken out to separate contractor, like was done for the offensive and defensive avionics suites on the B-1B, while the airframe becomes the contractual responsibility of yet another contractor. A serious question at this juncture becomes: Who will be the overall system integrator? Will it be the airframe contractor as is more often the case or will it be by design or by default, relegated to the government? These issues and decisions will become the foundation for the preparation of the WBS that ultimately influences detailed content of program SOWs.

There likely will be other organizations impacting or impacted upon by the acquisition process and, therefore, need to be considered in the WBS and SOW development. As examples, Air Training Command (ATC) may have a major responsibility for the system training program and it may be necessary to integrate ATC's level of participation into the SOW requirements. Equally important may be the role the Air Force Logistics Command may play by providing the contractor with common support equipment and system components currently in the Air Force or DOD inventory. Will the

FIGURE 1. SUMMARY AIRCRAFT WBS (MIL-STD-881A)



needed interfaces with these other organizations be made by the program office or by the contractor? The answer will certainly affect WBS and SOW content.

How does the contractor break down the WBS to the indentures below the top-three selected and tailored by the government? That is part of their system's engineering process. Our experience has been that most program management and design problems are at the sixth and seventh levels of the WBS, which are not visible at the aggregate top-three levels. Though this has been, at best, a cursory look at the formulation of a WBS, the major points still remain.

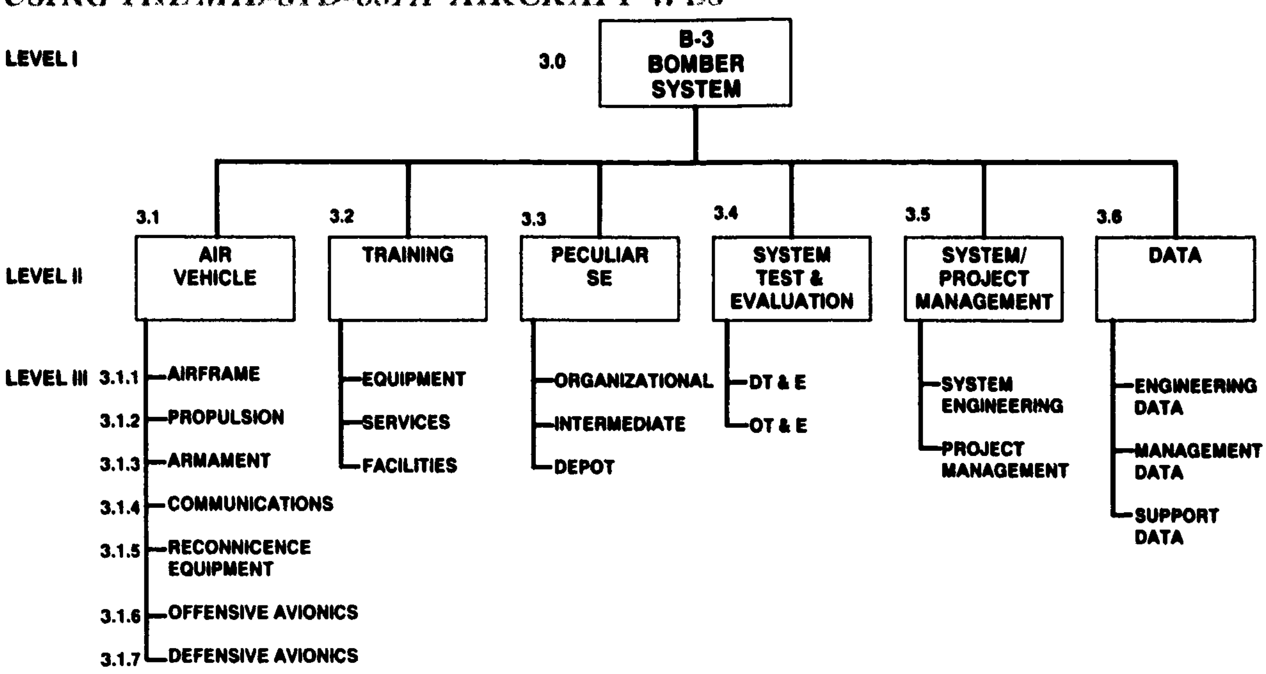
—The WBS helps identify interfaces within the government, between the government and contractor, and between contractors.

—The WBS identifies areas of responsibility regarding funding, schedules and future contract performance.

—The WBS provides a framework for integrating total program requirements.

The aircraft WBS format in Figure 1 can serve as an excellent starting point for SOW development (Figure 2). For

FIGURE 2. INITIAL FICTIONAL B-3 SOW DEVELOPMENT USING THE MIL-STD-881A AIRCRAFT WBS



instance, Level 1 would be the fictional B-3 Bomber System. Level 2 items could be labeled 3.1 air vehicle, 3.2 training, 3.3 peculiar support equipment, etc. Level 3 items would be sequentially numbered using the same beginning digits as its higher-level category; the airframe could be listed as 3.1.1 under the air vehicle indenture 3.1. Once all levels in the WBS are numbered, the program manager can proceed with the more complicated effort of writing the SOW tasking paragraphs. As mentioned, there are two distinct concerns to address when writing a SOW. One is preparation of a SOW in the proper format that follows fundamental do's and don'ts of SOW construction. The other is proper wording of technical and managerial taskings making up the work effort. Since the latter is the more difficult, how do program managers proceed with this arduous undertaking? According to results of our survey, program managers agreed that the most common method was to plagiarize from another program's SOW. One program manager's written response typified the majority perspective:

> It was common practice (in my SPO) to try to copy or modify an old SOW. Obviously, unless the programs are extremely similar, this is not a good approach.

There are inherent risks associated with copying an existing SOW, which probably was tailored to reflect program-unique requirements. Certainly the system acquired was unique. There may have been differences in the program phases, contract type, level of program scope and risk, incentives, or other program areas. A SOW is a derivative of all these factors. If you have the necessary skilled resources to scrub-out differences between the other SOW and yours, then you possess necessary skills to develop a *new* SOW using a systematic approach without reverting to plagiarism. The use of another SOW as a source of ideas is one thing, but outright copying without strict attention to appropriate tailoring could leave you with the same result as is suggested in the old saying about computerized informational databases—"Garbage In, Garbage Out (GIGO)."

Another "do" is to ensure that a SOW task makes sense. Try to look at it through the contractor's eyes. Slightly more than 900 program managers out of 1,036 agreed that the SOW is one of the most important documents prepared by the program office. Yet, in our SOW preparation we continue to include tasks not well thought out. Here are actual taskings taken from AFSC contract SOWs.

> Working with the base personnel at each base, the contractor shall determine the scope of System X required in order for the base to reach its initial operational capability (IOC).
>
> The contractor shall support Air Force planning efforts by attending meetings, conferences and reviews and responding to requests for information.
>
> The contractor shall conduct bimonthly program management reviews to provide a review of the contractor's program status to the program office.
>
> The contractor shall perform the logistics support analysis (LSA) process in accordance with MIL-STD-1388-1A and establish an LSA Record (LSAR) data file in accordance with MIL-STD-1388-2A. (Note: Tailoring of the MIL-STD-1388-1A taskings and 1388-2A data base elements will be accomplished at the LSA guidance conference).

The first three examples are vague and ambiguous, making them difficult to price. Will the contractor's pricing be a true and accurate representation of a government requirement? Example three has another potential problem by using the word "bimonthly." According to the *American Heritage Dictionary*, "bimonthly" can mean once every two months or twice a month. This may be a mundane example but it unquestionably points out the need to write SOW taskings that have only one interpretation. It would have been less confusing and easier to price if the tasking had said the meeting would be conducted twice a month or every two months.

In the last example above, this SOW requirement was found in a government solicitation officially released to industry for bid proposals. The problem in this case is that an LSA guidance conference is not held until after the contract is awarded. How are contractors supposed to price the LSA effort competitively when the government won't be finalizing the tasks until after the contract is let? Cost of performing the LSA process and creation of its accompanying data base is directly dependent on how many of the 82 MIL-STD-1388-1A subtasks must be accomplished, and which of the thousands of data elements contained in the MIL-STD-1388-2A data base are required. Cost of the LSA effort can fluctuate by millions of dollars on a large program, depending on the amount of MIL-STD tailoring performed. If the government did not want to do the tailoring, it should have tasked the contractor in the "Instructions to Offeror" (section L) portion of the solicitation to provide the contractor's recommended tailoring and cost in their proposal response. After negotiations are complete, proper tailored language can be inserted into the final SOW contract.

Some of you may be thinking the contractor won't nickel-and-dime us to death. They understand what we want and will live up to the spirit of the contract not the letter of the contract. It may not be our intention or the contractors, but when we put ambiguous words and requirements in a SOW, we make contractors mind-readers and may put them in control. Our experience has shown this to be possible, especially on fixed-price type contracts. Providing flexibility in SOWs should be something that is planned and in the best interest of the program. One survey respondent summarized this way. "SOWs should be in adequate detail for bidders to cost-out the effort, but broad enough to permit flexibility in their response; i.e., remember to convey what you want, but not how to do it."

Another common problem in writing SOWs is the improper tasking of the contractor to prepare data requirements. Both AFR 310-1 and MIL-HDBK-245B state that data are by-products of the work generated by the contractor's performance of SOW tasks. Data are to be ordered in the Contract Data Requirements List (CDRL) and only a reference to the data-item description identification number (DI-CMAN-80008) or the CDRL sequence number will be referenced at the end of a SOW tasking.

During a consulting effort involving review of a draft SOW for a major aircraft acquisition program, we identified 59 separate SOW taskings directing the contractor to prepare data. Of greater concern: In two of them the contractor was tasked to develop acceptance test procedures (ATP) and a configuration management plan. Nowhere in the SOW was the contractor told to perform the ATP or to establish and implement a configuration management program. The contractor should have been tasked in the SOW to "perform acceptance test procedures IAW the governments approved plan" and "establish and implement a configuration management program." The data by-products of this effort would be the ATP and configuration management plan data deliverables as ordered in the CDRL. The contractor would know of the data requirement needing development by the parenthetical reference to the data-item numbers at the end of the SOW task. A simple thought to remember: Any data deliverables ordered in the CDRL should not be identified in the SOW as a direct tasking for its development. This would include simple data products like agendas and minutes up to expensive ones like engineering drawings. Here are examples. Incorrect: The contractor shall prepare computer program test plans and procedures for integration of the built-in-test software into a central processing subsystem. (DI-XXX-XXXXX) Correct: The contractor shall integrate and test the built-in-test software in the central processing subsystem. (DI-XXX-XXXXX)

In the incorrect example the task is to "prepare plans and procedures," in other words DATA. Where is the contractor actually tasked to perform the integration or test? In the correct example, the contractor is tasked to do the "integration and testing" and the plans and procedures are the data by-products of the planning of these activities. The contractor is made aware that a data product relevant to this particular work effort has been ordered in the CDRL by the parenthetical reference to the data item at the end of the SOW task statement. These examples illustrate the relationship that must exist between the SOW and data by-products. The SOWs need to be coordinated with all functional managers so that data requirements can be combined, reduced or eliminated.

The team approach is necessary because it highlights one of the most important ingredients of the systems engineering process—people. It's the people who make the program work on the government and contractor sides. Why not use them effectively?

Education

Education and practical experience in SOW preparation are the best way to overcome some problems we described. Though we have been addressing the problem of SOW development, the problem is much deeper. If you don't have a well-rounded understanding of acquisition principles and processes it will be difficult to write a SOW. Recent initiatives resulting from the defense management review (DMR) have highlighted the need for better trained DOD program managers and acquisition support personnel. The DMR grew out of findings from the 1986 Packard Commission Report, which stressed the need for acquisition reform and improved educational opportunities for acquisition support. In fact, the Air Forces Acquisition Management Professional Development Program (AMPDP) was a direct outgrowth of the Packard Report. The AMPDP sets stringent guidelines for certifying acquisition personnel at three levels, which are indicative of their educational and experience background. Unfortunately, the courses required in this certification curriculum are far from adequate in meeting the need for SOW preparation.

The Defense Systems Management College (DSMC) Program Management Course highlights the SOW and its relationship to SPO objectives. Periodically, DSMC will conduct two- or three-day system engineering seminars where SOW preparation is part of the curriculum. We participated in one of these seminars at the Human Systems Division, Brooks AFB, Texas, and found it to be a very effective way of training.

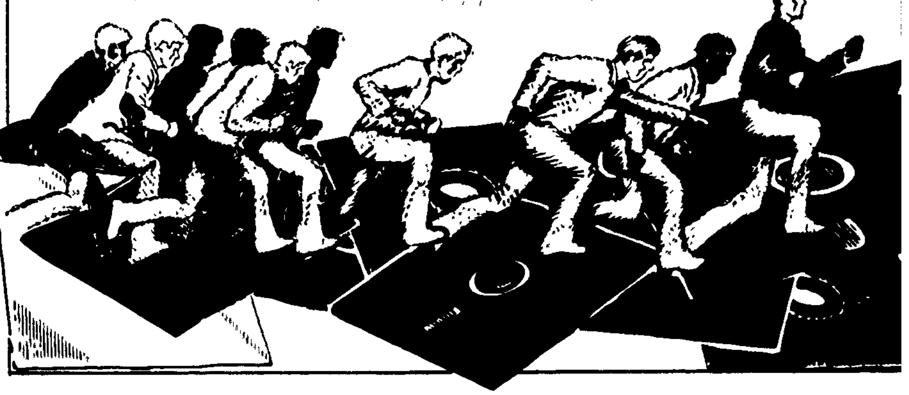
The Air Force Institute of Technology (AFIT) has courses regarding SOW development. The AFIT SYS 100 course is a 30-hour introduction to general program management responsibilities with a cursory discussion of the SOW and its purpose. The AFIT 3-week SYS 200 course of approximately 12 hours on basic SOW preparation skills includes practical exercises. Although SYS 200 concerns SOW development, available slots to attend the course are limited at this time to about 300-350 students per year. Considering the backlog of students wanting/needing to attend, it doesn't appear there are overwhelming opportunities available for education or training on proper SOW development techniques.

There are several automated tools available within the government to assist in SOW preparation. The most well-known is the modem accessible computer generated acquisition documentation system (CGADS),

(Continued on page 38)

APPLYING TOTAL QUALITY MANAGEMENT TO THE SOFTWARE LIFE CYCLE

pplying Total Quality Management (TQM) concepts to software development processes can dramatically improve our competitive advantage in the software arena. By capitalizing on the TQM approach, (i.e., designing and building quality into software, endorsed in DoD-STDs 2167A and 2168), a process is established that encourages error prevention and reduction, and fosters early error identification and resolution. Increased software development efficiency (productivity) also promotes: better understanding of the development environment and system requirements; reduced test through increased evaluation effectiveness (i.e., testing smarter, not more); and quantifiable measures for the evaluation process. This contributes to reducing acquisition and support costs by advocating a total life-cycle approach to software development, including modification efforts after the system is fielded (Figure 1).



Setting the Stage

As software-intensive systems continue to dominate modern commercial and defense system applications, software development, test, and evaluation play an ever expanding role in overall system planning and execution. Accordingly, it is imperative that the system development community have an understanding of how software, and total quality management application to the software processes and products, can impact the total integrated systems ability to meet technical, cost, schedule, operations and support objectives.

As TQM becomes increasingly institutionalized within commercial and defense development/acquisition processes, it is important to recognize that the TQM philosophy is equally applicable to the system's hardware and software elements. However, it must be understood that TQM leverage areas are different for hardware and software, thereby influencing planning and execution. While the TQM philosophy is the same for all system elements, applying TQM to software-intensive systems requires a different perspective to install and maintain management commitment to continuous improvement.

Total quality management takes a total life-cycle view of system development and production (Figure 2). For production programs, material, labor and overhead dominate life-cycle production costs. However, design and development is the predominant influence on life-cycle costs, with the smallest percentage of life-cycle product cost. Many of today's total quality management practitioners, across the full product process spectrum, while not ignoring design and development, concentrate on improvement in the material (production), labor (also production related) and overhead aspects. This, in part, may be due to the background of many of today's senior managers and their familiarity with hardware manufacturing.

While this perspective is valid for the hardware elements of the finished product, it must be noted that it is not

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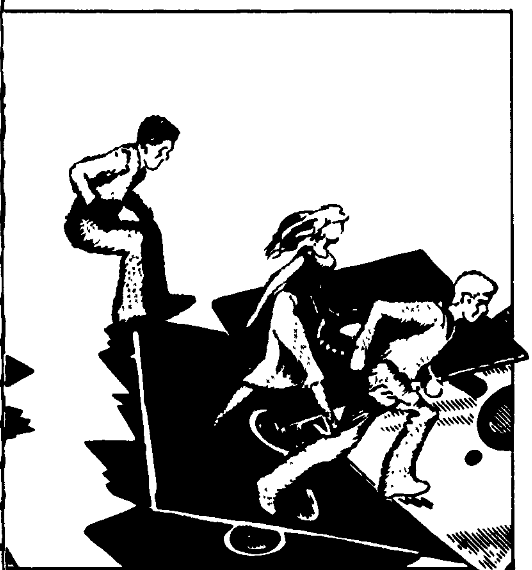
LTC Shumskas is military staff assistant, weapon systems assessment, Office of the Director of Defense Research and Engineering.



applicable for the system's software elements. For example, software production costs are basically negligible when compared to hardware production costs. In fact, the major element of software production costs is cost associated with hardware; i.e., electronic media (disks, read-only-memory) used to deliver software to the user.

Software may be different but it does not mean software is unmanageable. Consequently, a product's software elements also can benefit from total quality management application, when differences are recognized, understood; also when management makes a conscious decision to pro-actively manage and improve all processes and product elements associated with providing quality products to their customers. This improves their competitive advantages within either, or both, commercial and defense sectors.

Applying total quality management's total life-cycle perspective to the system's software elements, while recognizing differences associated with the software life cycle, presents a different set of considerations and process areas for exploitation in achieving continuous improvement (Figure 3). For example, there is a direct correlation between effort expended and product costs, with no significant impact on the relative percentages. However, effort expended directly acknowledges the labor-intensive activities associated with software development, operations and maintenance.

It is easily recognized that four leverage areas, requirements analysis, design code and unit test, and integration and test are directly associated with the software development process. Therefore, one could say that while operations and maintenance clearly dominate software's total life-cycle effort, development is the predominant influence on life-cycle effort.

Understanding software operations and maintenace activities can further clarify "true" software leverage areas. Typical operations and maintenance functions are: identifying and correcting previously existent errors, faults or failures undetected during initial development and test or maintenance and test; improving system performance without adding new capabilities (e.g., changes to account for system hardware enhancements or shortfalls), or to improve user interfaces; and enhancements to add new performance capabilities. All these are just different forms of software development activities.

Since software operations and maintenance are basically another form of development, it is possible to improve software's life-cycle costs and product quality by focusing on improving software development activities and applying development process improvements to the operations and maintenance phase. This has three benefits: development process improvements should produce higher quality software that meets user needs in the operational environment; higher quality software should require less maintenance to correct previously existent errors, faults, and failures; and improving the software maintenance (development) process should produce higher quality software that meets the user's needs with reduced errors, faults and failures.

Applying TQM techniques to software development presents a further refined set of process activities for analysis and improvement (Figure 4). As used here, "definition" includes requirements analysis; "design" is the application of software engineering discipline to translate requirements into a detailed "blueprint" that meets the requirements; "development" is the code ("manufacture") and integration of the software components into a functional, quality software product; test is the full gamut of activities associated with evaluating software's quality and performance levels from the unit level to the integrated, final product; and "pre-production" costs could be from either initial develop-

FIG. 1. [illegible]

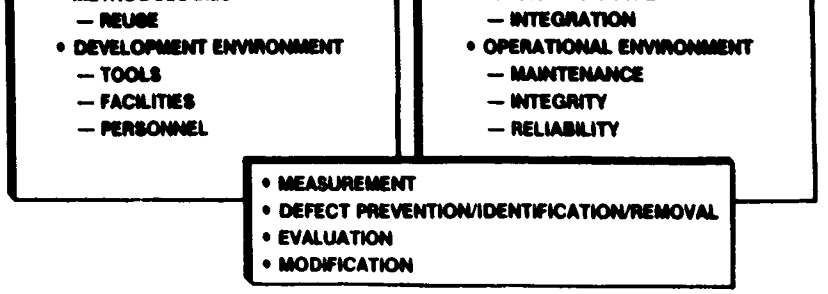
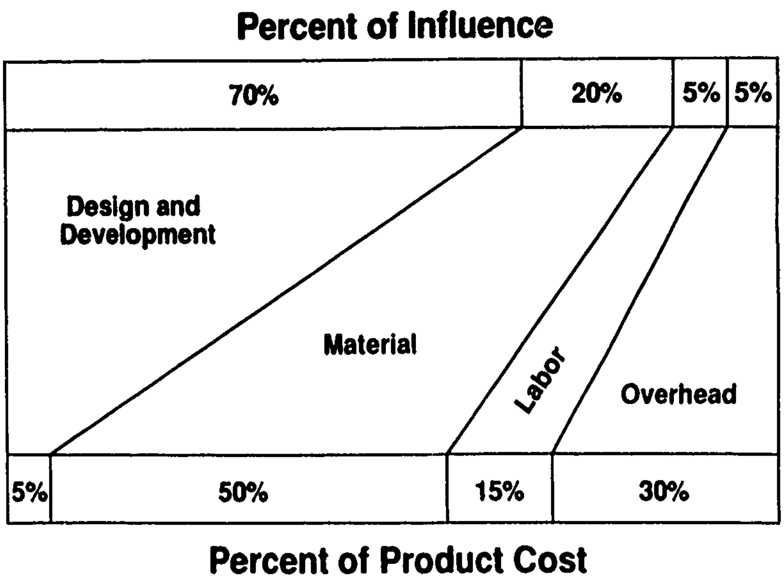


FIG. 2. TQM LEVERAGE AREAS



ment or specific software maintenance (development) activities. Again, there is a dichotomy, for while definition has the largest influence on software cost, test is the single largest opportunity for cost reduction.

Software definition adequacy, degree of software engineering discipline applied during design, and development process quality directly influence the extent and nature of software planning, execution, and evaluation. These interrelationships are important, especially in developing and maintaining today's software-intensive systems, where there is an up-front emphasis on designing-in quality, instead of testing quality into the product before customer delivery. Rigorous application of discipline and process knowledge will help to ensure that quality software-intensive system delivery to the customer is the norm and not an exception.

Prerequisites

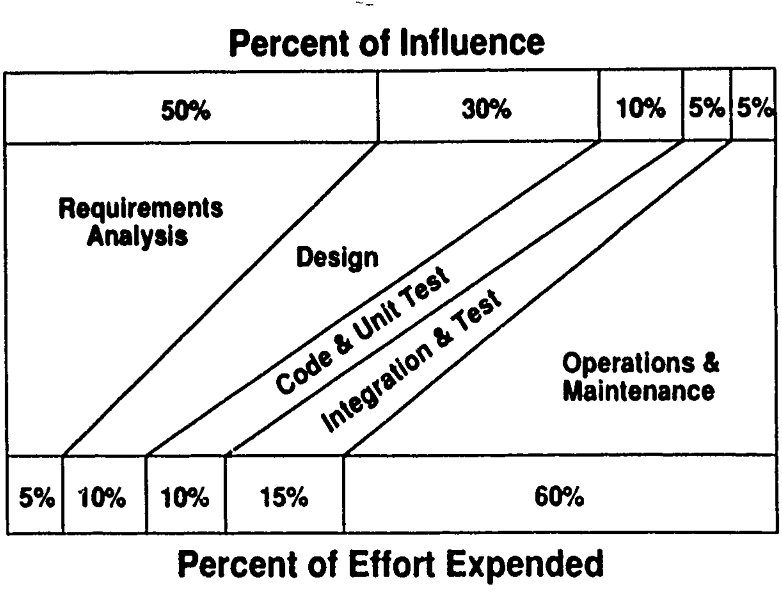
A 1982 Defense Science Board (DSB) report[1] concluded that multifaceted problems were associated with software development, but concentrated in two areas: management and status measurement. Similar concerns were expressed in a 1987 DSB report,[2] "Big problems are not technical. In spite of substantial technical development needed in requirements-setting, metrics and measures, tools, etc., the Task Force is convinced that today's major problems with military software development are not technical problems, but management problems." These DSB reports were reaffirmed by a 1988 Software Engineering Institute (SEI) report[3] which concluded, "not much change since 1982," but there was a "better understanding of problems."

Software development strategies' apparent failure to keep pace with the rapid software technology insertion growth is an argument often raised against many large-scale, software-intensive defense weapon systems. Opponents claim it is impossible to build perfect systems due to the magnitude of the software task. This can be countered by: (1) striving for perfection while recognizing limitations imposed by human foibles, and (2) defining and achieving an end-goal, not of perfection, but of satisfying customers needs (requirements).

Effective software development planning and execution must address four issues directly associated with TQM: (1) Where are you now? Define the known process, system technical and performance baselines, and current development status; (2) Where are you trying to go? Define the development effort's process, technical and operational performance objectives to be verified; (3) How are you going to get there? Define the measurement and evaluation program that will provide quantitative evidence to support process improvement, risk management and fielding of viable weapon systems; and (4) How do you know when you're there? Define the measures of merit that will be used to validate achievement of process, performance and technical objectives.

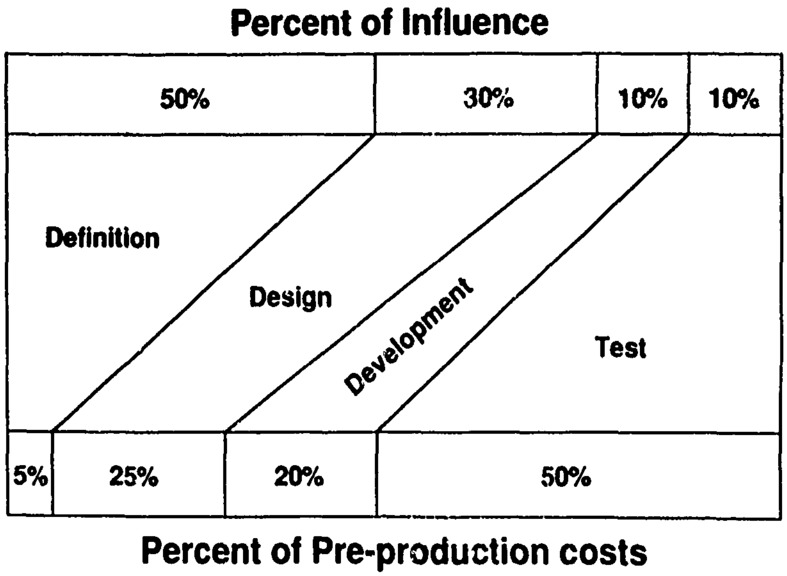
Successful TQM activities (i.e., ones striving for continuous process and product quality improvement) effectively use evaluation, measurement and test tools to: assess process

FIG. 3. SOFTWARE TQM LEVERAGE AREAS



status and product quality; foster early error identification and correction; and continuously apply error prevention methodologies. This combination of TQM practices and viable implementation procedures is available today. Using it provides quantifiable measures to build confidence and traceability during the system's life cycle and forms a basis for an improved software development and evaluation process, and true software-intensive system acquisition strategies.

FIG. 4. SOFTWARE DEVELOPMENT



To compare software development strategies, a basis for comparison is needed. A natural choice is cost, from perspectives of development cost and the cost of errors (in-efficiencies) (see Table 1) for each life-cycle phase. For each evolutionary strategy an estimate of software development and error costs are presented by life-cycle activity. Error is defined in ANSI/IEEE Standard 729-1983, "IEEE Standard Glossary of Software Engineering Terminology," as follows: "Human action that results in software containing a fault. Examples include omission or misinterpretation of user requirements in a software specification, incorrect translation or omission of a requirement in the design specification."

Development costs were obtained using the COCOMO software estimating model for a 100,000 line of code (LOC) effort. COCOMO (COnstructive COst MOdel) developed by Dr. Barry W. Boehm is described in Endnote 7. Based upon data collected on completed software development efforts, it includes development error detection and correction.) Nominal settings were used for all development environment factors, except product reliability, which was set at 1.15 to reflect military system application, and use of programming practices, which were set at 1.24 for traditional, 1.0 (nominal) for modern, and 0.82 for projected. For comparison, a constant dollar figure, $73.00. labor hour, was used.

Error costs and savings due to error prevention techniques were calculated using the following assumptions (in terms of errors remaining at time of initial software operation and maintenance, these assumptions are consistent with data presented by Bush[4]).

Humphrey[5] showed that up to 80 percent of developed software is error free. Applying this to 100,000 LOC implies that 20,000 LOC are affected by errors, but all errors do not affect just one line of code; i.e., one should not infer 20,000 errors. It was assumed, on average, one error af-

TABLE 1. SOFTWARE COSTS AND ERROR INTRODUCTION/DETECTION

SOFTWARE DEVELOPMENT PHASE	DEVELOPMENT DOLLARS	ERRORS INTRODUCED	ERRORS FOUND	RELATIVE COST OF ERRORS
Requirements Analysis	5%	55%	18%	1.0
Design	25%	30%	10%	1 - 1.5
Code And Unit Test	10%			
Integration And Test	50%			
Validation And Documentation	10%	10%	50%	1.5 - 5.0
Operations And Maintenance	--	5%	22%	10 - 100

fected five lines of code; e.g., the possibility exists for 4,000 errors.

Error correction cost is based upon actual data from Tiburon Systems, Inc.[6] The cost ratio across the cycle phases is consistent with data presented by Boehm.[7] Error insertion distribution is obtained directly from Table 1, slightly modified to recognize changes in phase terminology and/or breakout.

Productivity measures are traditionally based upon LOC/day or document pages/day, etc. Here, a non-traditional measure is proposed in terms of process efficiencies for preventing and detecting errors during the life cycle. This measure can be a better criterion for assessing productivity from the standpoint that, while rate of product development is important, product quality is the productivity driver. Process efficiencies for modern practices are obtained from Table 1, modified as above. Efficiencies for traditional practices reflect late life-cycle phase use of test to determine and improve product quality then in vogue. Projected strategy efficiencies reflect gains expected with consistent, effective application of the Ada environment, TQM management practices contained in DOD-STDs 2167A and 2168, and true application of software engineering discipline based upon applied mathematics.

Error prevention efficiencies were arbitrarily picked for traditional practices. Efficiencies were modified for modern and projected strategies to reflect anticipated changes in error prevention efficiency associated with application of TQM and improved development practices. Note: Actual error prevention efficiency data are unavailable.

In addition to development cost, it is imperative to consider software development strategy evolution in terms of a parametric model. For example, the formula for successful software development can be expressed as: Software, productivity, management, and quality equal improvement of people, policy, process, procedure and planning.

As software development strategies evolved, each strategy can be characterized by functional areas that were improved. However, all areas were not necessarily addressed in any particular phase. Despite improvement in one or more functional areas, failure to improve any one area can negate improvements in others. This is consistent with SEI methodologies to measure the capability/capacity of software developers to produce quality software products.[8] Accordingly, the appropriate SEI process level maturity is identified for each evolutionary strategy.

Traditional Approach (SEI Process Level 1)

A Level 1 (initial) organization has ill-defined procedures and controls. The organization does not consistently apply software engineering management or use modern tools and technology, and may have serious cost and schedule problems. Traditional development is identified by: (1) perceived infinite software flexibility; (2) lack of formal engineering (art verses science); (3) lack of process controls and management visibility techniques; (4) continuous software development is typically attempted, in essence, the prototype is the deliverable end-item; and (5) while hardware requirements are "frozen" prior to build, software requirements change throughout the development process.

At least seven out of ten major defense programs using the traditional approach strategy experience critical software-related problems that directly impact system-level cost, schedule and performance.[9] Traditional approach strategy attributes can be related to a combination of fear, mysticism and mythology. Fear arises from computer/software technologies and terminology. A direct outgrowth of fear is the mystique that these technologies can only be understood by software wizards, not system managers. This mixture produces myths that, over time, were proved to be wrong and costly.

Myths are often stated as follows: (1) Software only affects computers, not the system; (2) understanding software's impact on system performance is easily achieved, (3) test methodologies can easily detect, classify and allocate system errors to software; (4) test detects all software errors since the computer won't run if an error exists; (5) software is inherently flexible, therefore changes and corrections are easy; and (6) software performance requirements cannot be stated, measured or evaluated.

Traditional software development "strategies" are an "art form." Software is designed from the bottom up (from what developers already know, e.g., algorithms, equations, formulas, etc.) to what was now required; and tested by a best "guess" approach to what's required. When problems are found, software is fixed by programming judgment. This haphazard method produces monolithic, disjoint, complex programs full of "patches," "band-aids" and "nifty tricks."

Monolithic, disjoint structures often have "horror story" glitches, true development status or undiscovered critical errors that are seldom, if ever, found. Problems are left for the user to find. Software often is not properly tested, implying either systems test or nothing at all, except for problems discovery in compilation and/or assembly. Little or no management visibility into the software development process' progress, status and problems exists.

Programmers, software engineering predecessors, have great freedom from controls. No one," knows the jargon or how to develop software. Management's process and technical performance visibility, per se, is nonexistent. Software is a "black art," not engineering discipline, practiced by "wizards." Common measurement practices are the "90 percent Syndrome." ("90 percent Syndrome" refers to the generic answer for all software development questions. Where are we now? What remains to be done? When will we be done? The answer was: "The software is 90 percent done." There is no difference when these are considered. development beginning, during, or end; after fielding; or when the software was retired. The answer remained the same.)

As software life-cycle costs grow, the traditional approach is becoming unacceptable and unaffordable. Consider the hypothetical 100,000 LOC

TABLE 2. TRADITIONAL SOFTWARE DEVELOPMENT APPROACH COSTS

TRADITIONAL	EFFICIENCIES TEST & EVAL	PRO-CESS	POSSIBLE ERRORS	ERRORS PREVENTED	ERRORS REMOVED	ERRORS PASSED	COST/ ERROR	ERROR CORRECTION COST	ERROR COST AVOIDED
REQUIREMENTS	0.00%	5.00%	2,200	110	0	2,090	380	0	41,800
DESIGN	0.00%	25.00%	800	200	0	2,690	380	0	76,000
CODE	30.00%	10.00%	600	60	969	2,261	953	923,457	57,180
INTEGRATION	50.00%	25.00%	200	50	1,206	1,206	953	1,148,842	47,650
CSCI TEST	80.00%	35.00%	200	70	1,068	267	1,904	2,034,234	133,280
DEVELOPMENT (SUBTOTAL)	92.39%	12.25%	4,000	490	3,243	267		4,106,532	355,910
O&M					267	0	13,906	3,714,293	
TOTAL LIFE-CYCLE COSTS	100.00%		4,000		3,510	0		7,820,825	355,910

COCOMO COST ESTIMATE: $17,639,294

program (Table 2). The historical approach requires $17.6 million for development. Error correction costs incurred are $4.1 million, or approximately 24 percent of development cost. Error prevention activities avoided less than $0.36 million in incurred costs. From a life-cycle perspective, total cost incurred due to errors is in excess of $7.8 million, or 44 percent of development cost.

Current Approach (SEI Process Level 2-3)

A Level 2 (repeatable) organization has learned to manage cost and schedule, has a repeatable process and uses standard methods and practices for managing software development activities; e.g., cost estimating, scheduling, requirements/code changes, and status reviews. At Level 3 (defined), the process is characterized and reasonably understood. The organization defines its process software engineering standards and methods, and makes a series of process improvements, including: design and code reviews, training programs, and increased commitment to software engineering. A major improvement over Level 2 is the establishment and staffing of a process improvement group that focuses on software engineering (based on applied mathematics, not art"), the software engineering process, and the adequacy with which it is implemented.

The current approach is characterized by: (1) disciplined software design processes to replace monolithic design practices; (2) efforts to obtain quantifiable software measures; and (3) early stage application of Ada, including the Ada development environment, and structured, consistent software development, quality, test and evaluation practices, and software measurement.

Ada promotes proactive engineering discipline in the software development process. The Ada environment adds an "object-oriented" perspective to the traditional "top-down" approach to requirements definition and implementation. This enhances the requirements definition and analysis processes by producing quantitative, objective requirements and performance levels; i.e., quality attributes, to be measured and verified through test, analysis and evaluation.

The DOD-STDs 2167A and 2168 define management structure, not technical structure, for software development and support; and provide a consistent DOD approach for implementing viable evaluation techniques. Capitalizing on these standards, DOD 5000.3-M-3 provides for incorporating software reliability, test, and evaluation into defense system planning activities by requiring defense system developers to identify specific software performance objectives in a system's context and measures of merit to verify objective achievement.

Software measurement directly relates to the ability to obtain visibility into the development process and products. Complexity and perceived data intensiveness associated with using the DOD-STD-2167A software quality factors have inhibited domestic software measurement applications. While software measurement has not reached a maturity which allows consistent interpretations of each factor, early application of metrics have provided preliminary results that indicate direct linkage between measurement, management visibility, and reduced development costs. When organizations recognize this linkage between measurement and active management process control and improvement and initiate a software measurement program responsive to management needs, they take a large step in progressing from Level 2 to Level 3.

Software indicators counter the perceived data intensiveness of software measurement, and provide management insight into development process and software product quality. Indicators, though not absolute, combine planning goals and

TABLE 3. CURRENT SOFTWARE DEVELOPMENT APPROACH COSTS

CURRENT	EFFICIENCIES TEST & EVAL	PRO-CESS	POSSIBLE ERRORS	ERRORS PREVENTED	ERRORS REMOVED	ERRORS PASSED	COST/ ERROR	ERROR CORRECTION COST	ERROR COST AVOIDED
REQUIREMENTS	20.00%	20.00%	2,200	440	352	1,408	380	133,760	167,200
DESIGN	25.00%	25.00%	800	200	502	1,506	380	190,760	76,000
CODE	30.00%	30.00%	600	180	578	1,348	953	550,643	171,540
INTEGRATION	50.00%	50.00%	200	100	724	724	953	690,067	95,300
CSCI TEST	80.00%	80.00%	200	160	611	153	1,904	1,163,877	304,640
DEVELOPMENT (SUBTOTAL)	94.77%	27.00%	4,000	1,080	2,767	153		2,729,108	814,680
O&M					153	0	13,906	2,125,115	
TOTAL LIFE-CYCLE COSTS	100.00%		4,000		2,920	0		4,854,223	814,680

COCOMO COST ESTIMATE: $14,225,237

trend data to enhance the evaluation process, provide status assessment tools, and data for research community use in calibrating software metrics. Originally published as Air Force Systems Command Pamphlets 800-14 and 800-43, the Army Materiel Command has adopted this concept, and the Navy is preparing their versions of these documents. The Institute of Electrical and Electronics Engineers (IEEE) has adopted this approach in their *Guide For The Use Standard Dictionary of Measures to Produce Reliable Software*.

The software requirements process has improved through use of Ada, DOD-STDs 2167A and 2168, DOD 5000.3-M-3, and commercial and professional society standardization efforts. These provide mechanisms for defining quantitative software characeristics/thresholds for incorporation into system-level characteristics/thresholds. Proactive management advocates capitalize on this foundation to implement measurement and evaluation techniques, metrics or indicators, to meet management requirements. This enhances the ability to define development and test requirements, and leads to quantitative techniques for measuring success. These initiatives help establish quantifiable measures that permit confidence building and traceability across the life cycle.

Current practices provide a significant savings over the traditional software acquisition approach. For the 100,000 LOC program, development costs declined from traditional approach cost by $3.4 million to $14.2 million. In large part, savings are attributed to the 33 percent reduction in error correction cost to $2.7 million and the 129 percent improvement in error prevention savings to $0.81 million. From a life-cycle perspective, total cost directly associated with error correction has been reduced by 38 percent to $4.8 million. (Table 3.)

Projected Approach (SEI Process Levels 4-5)

A Level 4 (managed) process is understood, quantified, measured, and well controlled. The organization bases its operating decisions on quantitative process data; i.e., analysis and use of software measurement data gathered during software engineering reviews and tests. Tools are used to control and manage development, evaluation and test processes, and support data gathering and analysis. The organization is learning to project expected errors and applying software engineering discipline (using applied mathematics, including statistical analysis) to detect, prevent and reduce them.

Level 5 (optimized) organizations have a high degree of process control, and a major focus on improving and optimizing operations. This includes more sophisticated analyses of the process' error and cost data and introduction of comprehensive error cause analysis and prevention studies. Process data are used iteratively to improve the process and achieve optimum performance.

This approach builds on current initiatives and application maturity associated with their use. For application software development, measurement, test and analysis, it capitalizes on institutionalized use of true software engineering discipline, effective software engineering environments, and automated tool sets. Through synergistic effects of current initiatives, it is possible to significantly improve reliability of software intensive defense systems, while reducing the amount (cost) of testing and improving test efficiency. This is achieved by effectively applying TQM concepts to defined, measured and understood software development, test, and evaluation processes.

The projected approach requires three basic elements. discipline and knowledge of the process and products, requirements definition and understanding, and attributes that can be measured throughout the system's life cycle to verify requirement satisfaction.

Error introduction's primary source during the development process is the requirements phase (Table 1). Among the dominant causes for high-error insertion are incomplete, or misunderstood, requirements (especially derived requirements for the system's software components) and improper implementation of requirements; i.e., requirements and design errors. Requirements errors are reduced through a requirements analysis process that combines engineering discipline, human verfication and statistical evaluation (e.g., requirements definition, stability and completeness) to refine/define system requirements, including derived software requirements, to a level of understanding compatible with the software's functional criticality.

Process evaluation techniques (resource utilization rates, test and development status, and cost/schedule deviations) help early identification of critical software design features or functions, requiring increased management and engineering attention to prevent error introduction and/or increased analysis, including test, to ensure critical error detection and correction.

Product evaluation techniques (applied mathematical analysis) and statistical measures (error rates, correct outputs ratios, requirements traceability, test coverage, test sufficiency, and documentation indexes) are used, during requirements analysis, to ensure critical error detection. This provides management insight into the degree of success associated with employed error/failure prevention techniques. Prevention and early detection supports identification and development of required test scenarios to exercise software in ways truly representative of the user's environment.

A key ingredient in obtaining high reliability software is discipline. Commitment to TQM methods to improve process and products is but one aspect of required discipline. Another aspect is effective management control of requirements (stated and derived) creep during development. Requirements baselining to obtain a known, verified, reliable software product is essential to reducing risks. This is the essence of evolutionary software acquisition, i.e., build upon existing capabilities to add new enhanced capabilities.

"Grand Designs" of software-intensive systems is a major factor in the failure to provide quality software-intensive systems on time, within cost and schedule, and responsive to user requirements. Therefore, many development efforts use "evolutionary" methods to field systems, by building a "limited capability" system, with planned growth capabilities and related development activities to mature performance over time and capitalize on customer feedback. The primary focus is to maintain system performance integrity.

With well-defined requirements, "stress" test scenarios can be defined to ensure software products are tested and evaluated in a user representative environment. This increases software reliability, but does not necessarily ensure error-free software. Test discovers the presence, not the absence, of errors. Undiscovered errors remaining after user representative stress testing should have no serious impact on overall reliability. This results in using test to verify achievement of performance levels, rather than the traditional use of test to define "acceptable" performance levels.

The TQM techniques, defined requirements and system criticallity determine software components needing engineering and management emphasis throughout the development process. Statistical and engineering discipline techniques (sampling theory and mathematical proofs of correctness for software) reduce software development process errors from current industry averages of 20-40 errors per thousand LOC (KLOC) to less than 5 errors per KLOC.[10] Using TQM techniques early to improve requirements analysis, definition, and implementation increases up-front costs, typically between 5-12 percent above traditional costs. While additional costs can be considered relatively small, total development and life cycle cost reductions can be substantial.

Balanced TQM and development methodologies result in identifying specific measures of merit, attributes, and associated performance thresholds to be acheived during development. They promote and measure software reliability and performance characteristics. Effective and productive attributes meet three criteria: be consistent, objective and quantifiable measures; be usable for requirements articulation and subsequent evaluation of actual capailities; and provide traceability, or audit of maturity, across the development process. Candidate measures are identified in DOD 5000.3-M-3, DOD-STDs 2167A and 2168, the various Service software indicator pamphlets, IEEE Std 982-1989, and RTCA/DO-178A.

These candidates meet the prerequisite criteria. They are not complete, nor must all be used. To be effective, conscious-management decisions must identify, implement and use only measures that contribute to developing a software-intensive defense system that meets defined performance and mission requirements. Blindly requiring all available measures uses too much data collection and analysis resources, without a commensurate return on investment (ROI).

The projected approach provides a significant ROI from current practices. Development costs declined by $2.6 million to $11.7 million. The decline can be attributed to a 82 percent error correction cost reduction to $0.48 million and a 124 percent error prevention increase to $1.8 million. Total life-cycle error correction costs are reduced by 87 percent to $0.63 million. (Table 4.)

Summary

Software development is human intensive, thus inherently error prone. Existence of software errors does not *a priori* make software unreliable. Reliability is based upon user experienced failures, not remaining software faults. Reliable software needs to be fault-tolerant, not error free. More than half of IBM commercial software products have mean-time between failure rates greater than 1500 years.[11] Software-intensive defense systems should de-

TABLE 4. PROJECTED SOFTWARE DEVELOPMENT APPROACH COSTS

PROJECTED	EFFICIENCIES TEST & EVAL	EFFICIENCIES PRO-CESS	POSSIBLE ERRORS	ERRORS PREVENTED	ERRORS REMOVED	ERRORS PASSED	COST/ ERROR	ERROR CORRECTION COST	ERROR COST AVOIDED
REQUIREMENTS	80.00%	80.00%	2,200	1,760	352	88	380	133,760	668,800
DESIGN	80.00%	25.00%	800	640	198	50	380	75,392	243,200
CODE	80.00%	10.00%	600	480	136	34	953	129,303	457,440
INTEGRATION	80.00%	25.00%	200	160	59	15	953	56,357	152,480
CSCI TEST	80.00%	35.00%	200	160	44	11	1,904	83,447	304,640
DEVELOPMENT (SUBTOTAL)	98.63%	80.00%	4,000	3,200	789	11		478,259	1,826,560
O&M					11	0	13,906	152,365	
TOTAL LIFE-CYCLE COSTS	100.00%		4,000		800	0		630,624	1,826,560

COCOMO COST ESTIMATE: $11,664,694

mand at least the same. The projected approach supports this assertion.

Synergistic use of available development and evaluation techniques (engineering discipline, process standardization, requirements analysis, measurement methodologies and TQM approaches) returns meaningful balance to the software equation. This balance produces significant cost savings for software development and achieves defense system software reliability figures at least equal to those obtained with commercial software products.

Achieving balance requires the application of management commitment. Any additional early expenditures will be more than offset by: improved requirements definition and implementation; error prevention and early detection/correction; and a test program focused on verifying requirements achievement instead of establishing requirement specifications.

Studies by Sunazuka (et al) and Murine[12, 13] have shown the following benefits are achievable through application and use of evaluation techniques, in essence applying TQM to the software development process. up to 35 percent development cost reduction; approximately 50 percent reductions in test time and cost, and 50 percent reduction in documentation to define specifications, with a corresponding increase in specification readability and understandability.

In light of ongoing defense expenditure reductions and the increased competition for limited resources, cost alone should provide sufficient motivation for discarding the traditional approach entirely, and actively pursuing transition from the current to the projected approach. For example, if an organization only achieves the 50 percent reduction in test costs by applying TQM to the development process, recognizing that test consumes 50 percent of the total development cost (Figure 4), that organization has a 25 percent competitive advantage over those who fail to progress.

Endnotes

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* *The Department of Defense implementation of the Defense Management Report will incorporate DODD 5000.3 and DOD 5000.3-M-3 into two new documents: DOD Instruction 5000.2, "Defense Acquisition Management Policies and Procedures," and DOD 5000.2-M, "Defense Acquisition Management Documentation and Reports."*

IN MEMORIAM

William E. Rogers Adjunct Professor at DSMC

Mr. William E. Rogers, 57, director of logistics at Martin Marietta Denver Aerospace, and honorary professor of the Defense Systems Management College since March 1983, suffered a massive coronary February 23, 1991.

Mr. Rogers was a 1956 graduate of Kansas State University with a major in business administration and a minor in electrical engineering. He obtained a FCC first class radiotelephone license while attending college, and afterward was an officer in the U.S. Army Signal Corps. He joined Martin Marietta in 1958 and worked every discipline in logistics. In 1978, he was selected integrated logistics support department manager.

Mr. Rogers amassed a wealth of logistics knowledge and shared these experiences through workshops—whether they be international, the Society of Logistics Engineers, or in-plant seminars--and the DSMC Management of Life Cycle Cost Course (MLCCC) and the Management of Acquisition Logistics Course (MALC). He was recognized in the logistics community as an innovator in mathematical modeling techniques for logistics and life-cycle cost analysis. He developed many original models and converted numerous existing models to run on programmable calculators instead of the more expensive large-scale computers. Mr. Rogers directed the first symposium on "Quality." He was an avid supporter of the College Total Quality Management Course and enthusiastically promoted an understanding of the quality improvement philosophy.

Mr. Rogers was a senior member of the Society of Logistics Engineers, selected by the Institute of Cost Analysis as a Certified Cost Analyst and, in December 1990, became one of the first DSMC adjunct professors.

Mr. Rogers showed integrity, dedication to truth, and a search for knowledge by demonstrating and defining instructions as a professor and teacher.

He is survived by his wife, Arlene, and daughter, Susan, of Denver, Colorado.

INTERNATIONAL ARMAMENTS COLLABORATION

In times of economic and political stability, it is sufficient to "train" defense and other officials working in the international arena of arms collaboration. In stable times, the how-to-do knowledge can be imparted mechanistically.

In times of economic and political instability or permanent dynamics, training must be supplanted by "education" about the driving forces of all possible future partners in order (a) to conduct international collaborative defense programs without the prior experience of a frozen paradigm, and (b) to develop a rational guess about possible results, impacts and outcomes of negotiations in the international arena.

In short, in the future we will need to know more about our partners. What is their legal reference line, their economic system, their civilian and defense acquisition system, their cultural preferences and so forth? How do they see the world?

Hence, education "for the future" must go to legal, economic and social principles, to the cultural drivers and, possibly, national psychology. This "general knowledge" will enable future defense officials to develop their own strategy for international armaments collaboration and to live without the cookbook knowledge acquired in "training."

The cookbook for the future cannot be written.

Mr. Kwatnoski is a Professor of Engineering Management, Executive and International Department, Defense Systems Management College. He is the Course Director for the Advanced International Management Workshop.

n June 1985, the Secretary of Defense issued a memorandum to the Military Departments, the Joint Chiefs of Staff, Directors of Defense Agencies, and the Under and Assistant Secretaries of Defense placing renewed commitment and emphasis on NATO armaments cooperation.[1] The Secretary requested that seven new steps be taken, the seventh is my topic for this article.

This step requested an education program ... to develop and maintain appreciation for the significance of the individual role in furthering of collective security through armaments cooperation. There was bad news and good news.

The bad news was that the education step was last on the list.

The good news was that we finally made the cut.

This article concerns what has been done during the last 5 years, what we are doing now, some parallels with international education in the private sector, and where I believe we should go from here.

I should point out at this time that the Defense Systems Management College (DSMC), Fort Belvoir, Virginia, is the *only* educational institution in the Department of Defense offering courses in armaments cooperation. These are the Multinational Program Management Course and our new Advanced International Management Workshop. I will elaborate more about these armament cooperation courses and the workshop later in this article.

To avoid confusion about various kinds of international defense programs, I will confine my remarks to cooperative programs. These are programs where the United States and at least one other NATO nation (or other designated Ally) make an equitable contribution to the full cost of the program and participate in joint management of the program.

The projects may be for research and development, testing, evaluation, or joint/concurrent production (including follow-on support) of defense articles.[2] These exclude direct commercial sales of defense articles and foreign military sales under the Security Assistance Program.

Furthermore, I will use the terms cooperation and collaboration interchangeably.

The Past

In August 1987, DSMC completed a survey of 155 graduates of our Multinational Program Course.[3] These were students who had graduated from the course from one to no more than two years before conducting the survey. The makeup of the graduates was 84 percent Department of Defense (DOD) military and civilian, 8 percent, industry, and 7 percent, allied nations. Results of that survey were clear. It indicated that DSMC had been responsive to the needs of its customers, but due to changes occurring around that time, especially the Nunn[4,5] and Quayle[6,7,8] Amendments, and the evolving nature of international defense programs, many additions and improvements could be integrated into future international activities of the DSMC. These former students felt that the most useful aspect of the course was a broadening in perspective—imparting an understanding of both the variety of viewpoints and the difficulty of prob-

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EDITOR'S NOTE: *This is Part I of III of a paper, "The Problem of Training and Educating Defense Officials in the Arena of International Armaments Collaboration." Part II by Dr. Franz A.P. Frisch and Part III by Dr. Rolf Clark, both of DSMC, will appear in subsequent issues.*

lems in the international arena. This led us to conclude that this course was an excellent baseline from which to expand and incorporate many of the suggestions from the survey and other sources. The survey report also made 10 specific recommendations, the majority of which DSMC has been able to implement.

Two years later we initiated another survey of armaments cooperation educational needs.[9] This time it was directed to program management offices, selected DOD personnel, and attendees at a seminar in London, conducted by the Defense Systems Management College. This survey obtained 177 responses, at a remarkable rate of more than 60 percent. The results indicated a very strong need for education or training in international program management. Only 12 percent of the respondents felt that existing educational opportunities were adequate. Eight specific areas of knowledge or understanding were identified by more than 30 percent of the respondents as being essential to their jobs. Three areas stood out as being *very necessary* to all respondents as well as being rated as essential to more than 40 percent of the respondents with international involvement. These were:

—DOD policy related to technology transfer

—DOD policy related to international security

—International Memoranda of Understanding.

The topic of establishing contractual arrangements also ranked very high. In fact, the PMO respondents with international involvement rated this area highest. Closely following these important areas came four additional ones which were considered *necessary* to all respondents, and rated essential by at least 30 percent of those with international involvement. These were all related to the DOD policy for:

—Foreign Military Sales

—License Arrangements

—Coproduction

—Codevelopment.

Conversely, the areas of knowledge clearly determined to be least necessary to the respondents with international involvement were the following:

—NATO Organization and Functions

—Acquisition of Foreign Weapons Systems.

I will save my remarks on how DOD is responding to these findings to when I get to the present and future activities.

I would now like to move on to the most recent examination of the topic of armaments cooperation education. This examination was conducted by a committee of participants at the "Bonn Seminar on Armaments Cooperation" in July 1989.[10] Educational issues were addressed by this committee. Their report included a recommendation for management resolve to educate a dedicated corps of international armaments cooperation experts. This committee, consisting of representatives from the United Kingdom, Germany, France, Norway and the United States, felt that education resources were inadequate or non-existent when viewed in relation to the number of people needing the training, like offices of defense cooperation, security assistance offices, research and development support groups, ministry/department of defense staffs, international program offices, industry personnel, educators and the public. The committee concluded that the national schools should:

—Evaluate current courses taught in the national schools to determine how education can be used more effectively to achieve better armaments cooperation. They made specific recommendations about resident instruction, an entry-level course, mid-level courses, and a senior-level short course.

—Develop a "how to" cookbook on international armaments cooperation procedures, processes, organizations and guidelines.

—Develop correspondence courses.

The committee further concluded that:

—Trained and experienced armaments cooperation personnel should be identified in the work force, and their careers managed to ensure repeated international assignments and career growth.

—There should be oversight of the education system by high-level managers responsible for international armaments cooperation.

—Universities should be encouraged to include armaments cooperation issues, policy and processes in their international curriculum.

—Professional associations should be encouraged to sponsor seminars on international armaments cooperation issues.

A final examination of the question of training in international armaments cooperation came during exhaustive interviews of six international program managers as part of a comprehensive research study of international program facilitators of, and barriers against, success.[11] The following question was asked. "Could you or a member of the PMO staff have benefitted from training in the management of international programs; and, if yes, what area/topics would have been useful?" The question was posed to the program manager for the NATO Anti-Air Warfare System, the Autonomous Precision Guided Munition (155MM), the Modular Standoff Weapon, the Rolling Airframe Missile, the Multiple Launch Rocket System (Terminal Guidance Warhead), and a sixth program which provided responses on the basis of non-attribution. Five of the six responded "yes," whereas the one responding negatively said that "good people with a good work ethic" was more important. Of course, "good people" might imply experience and/or training. Four of the five positive respondents identified training in the area of allied nation processes, such as decision-making, funding, contracting, tax structure and acquisition.

As one can readily see, much has been done to analyze education in armaments cooperation, just as the Secretary of Defense requested 5 years ago. I would now like to address what actually has been accomplished, and provide some remarks on where I believe we should be going.

The Present

As mentioned, the Defense Systems Management College is the only DOD educational institution having a program for international armaments cooperation. This program was described in detail in an article I wrote for the January 1989 issue of *Program Manager*[12] and the Spring 1989 issue of the *DISAM Journal*.[13] The following is a brief description. Our educational program has three major components:

—The Multinational Program Management Course (MPMC)

—The Advanced International Management Workshop (AIMW)

—The International Defense Educational Arrangement (IDEA).

The first, the Multinational Program Management Course, is the foundation of the DSMC international armaments cooperation educational program. It is the baseline course for all those entering this field. Key national, DOD and Service policies on international codevelopment, coproduction and logistics are explored. We offer this course seven times a year.

The second, the Advanced International Management Workshop, is a focused and advanced workshop on international negotiation and acquisition management. Participants gain detailed knowledge of and practical skills in:

—International Memoranda of Understanding

—Preparing, negotiating and staffing international agreements

—Specific negotiation issues

—Factors resulting in successful international programs

—Congressional interaction in cooperative programs.

This workshop has received considerable interest and support from the Office of the Secretary of Defense (OSD) and all the Services. Nearly a quarter of a million dollars was invested by OSD and the Services in workshop development and materials. The DSMC spent more than a year, with contractor support, in developing the workshop. Our first production offering was June 18-22, 1990, and recently was described in *National Defense*.[14] We anticipate offering three workshops a year.

The third, the International Defense Educational Arrangement, is a grouping of national defense educational institutions with similar goals whose mission is to improve the economy, efficiency, and effectiveness of international training and education for acquisition management. Current members are the United States (represented by DSMC), the United Kingdom (represented by the Royal Military College of Science), and the Federal Republic of Germany (represented by the Federal Academy of Defense Administration and Technology). Additional national defense educational institutions sharing their goals are encouraged to join.

I would like to mention that there are several other government organizations offering short courses that could be beneficial to someone in a cooperative defense program. The Defense Institute of Security Assistance Management (DISAM) offers extensive training in foreign military sales procedures and the Security Assistance Program. The U.S. Office of Personnel Management (OPM) offers courses on foreign policy, national security policy and technology transfer, as well as occasional seminars on trade and foreign-policy issues. Additional specialized courses exist, like the NATO Staff Officer Orientation Course at the National Defense University and the Cross Cultural Communications Course at the USAF Special Operations School.

No summary of training opportunities in international armaments cooperation would be complete without mentioning two offered in English by our Allies. The first is the Management of International Projects offered by the Royal Military College of Science in Shrivenham, United Kingdom. This is a five-day course for senior managers with responsibilities involving international programs from the staff of the Ministries of Defense of NATO and the defense industry. Topics covered are concepts of collaboration, memoranda of understanding, international management structures, industrial and technical issues, and contracts and finance. It is offered three times each year.

The second training opportunity offered in English by our Allies is the EURO/NATO Training Weapons Systems Management Course by Industrieanlagen - Betriebsgellschaft mbH (IABG), a company working with the Germany Ministry of Defense, located in Ottobrunn, Germany (a suburb of Munich). This is a two-week course for middle- and senior-management personnel in the field of project management as practiced in the development, procurement and utilization of defense materiel. Course objectives address the management of NATO armaments programs, international armaments cooperation, life-cycle tasks and decisions, and exchange of experiences among NATO partners. It is offered only once each year in the early fall. It is open to all NATO nations on a quota basis.

This completes my summary of current activities in armaments cooperation education.

Parallels with Private Sector

I would like to draw some parallels between our efforts at the Defense Systems Management College in international training for defense officials and what is occurring in the private sector. A recent article found in the *Training and Development Journal*[15] presents a statement that "...most business leaders say that intercultural skills training is essential, but few do anything about it." Citing a survey of 55 presidents and chairpersons of *Fortune* 500 firms, all agreed that "most business firms (domestic as well as multinational) will be directly or indirectly affected by economic and political developments in the international scene. Businessmen will therefore need to understand and anticipate these efforts." However, citing another survey of multinational U.S. companies, only 12 percent said they offered seminars and workshops on cross-cultural aspects of doing business in foreign countries.

This dismal picture was reinforced by a more recent article in the

Management Development Report.[16] Citing an executive survey, 40 percent of respondents said that international business is currently a significant part of their overall business, and 60 percent reported that international business will increase during the next three years. This article further stated "numerous studies report that 70 percent of American business people who are sent abroad are given *no* advance training or preparation." Academia is responding to the international needs of business either by more integration of international aspects into basic classes or increasing specifically international courses. The situation and trends in academia are well summarized in a recent article in *North America International Business*.[17]

Regrettably, no similar set of statistics exists for international acquisition personnel in the government.[18] There may be no need for such statistics if one believes that defense acquisition personnel respond to government policy, rather than market forces. Defense policy had been determined in the past primarily by our national security interests. Recent trends in business globalization suggest that the way DOD approaches acquisition may become more influenced by economic forces, both domestic and international.

The Future

I would like to make a few remarks about the future. These remarks are based upon the surveys and studies I previously discussed, as well as my own views.

I see a need for integrating international aspects into all basic domestic acquisition courses.

I see a clear need for more, mid-level international courses. Specifically, three opportunities stand out:

—A course on technology transfer, defense product export control and international security.

—A course on the government aspects of international defense business management, particularly focusing on contractual aspects, financial aspects, licensing arrangements and offset agreements.

—A course on allied nation processes for defense acquisition, decision-making, contracting, funding and taxation.

A brief executive-level offering might be useful for senior personnel who have recently become a part of the international process, or wish to be refreshed on current topics.

A special offering emphasizing cooperative opportunities in the Pacific Rim might be appropriate—especially important in light of the turmoil and lack of clear direction regarding defense policy in Europe.

Finally, I would like to see a computerized management information and decision support system on international defense agreements be developed—one that could be accessed interactively by our negotiators. For example, while we were negotiating the memorandum of understanding for the Japanese fighter support experimental (FSX), it may have been useful to have available all precedents regarding technology transfer language found in other approved agreements. Ultimately, the ideal would be a system that could assess the impacts on cost, schedule, performance and supportability of an international program versus a national program.

As you are now aware, we have come a long way but have a long way to go in international armaments cooperation training and education, as you will see in the two future articles to be run in issues of *Program Manager*.

Endnotes

1. Memorandum from the Secretary of Defense, Subject: "Emphasis on NATO Armaments Cooperation," June 6, 1985.

2. Memorandum from the Secretary of Defense, Subject: NATO Cooperative Projects, Jan. 28, 1986.

3. *Multinational Program Management Survey Report*, Richard Kwatnoski, DSMC internal document, August 1987.

4. Public Law 99-83, Section 115, Amendment to the Arms Export Control Act, entitled: "North Atlantic Treaty Organization Cooperative Projects," 1985.

5. *Ibid.*

6. Public Law 99-145, Section 1102, FY 1986 DOD Authorization Act, entitled: "Acquisition of Defense Equipment Under North Atlantic Treaty Organization Cooperative Projects."

7. Public Law 99-661, Section 1103, FY 1987 Defense Authorization Act, entitled: "Cooperative Projects."

8. *Ibid.*

9. *Multinational Program Management Questionnaire Report*, Michael G. Krause, DSMC internal document, May 1989.

10. *Bonn Seminar on Armaments Cooperation*, proceedings, cosponsored by DSMC, Royal Military College of Science, and the Federal Academy of Defense Administration and Technology, July 17-21, 1989.

11. Interviews conducted by Lt. Col. C. Michael Farr, USAF, unpublished, circa summer, 1989.

12. "Educational Initiatives in International Armaments Cooperation," *Program Manager*, Richard Kwatnoski, January-February 1989.

13. "Educational Initiatives in International Armaments Cooperation by the Defense Systems Management College," *The DISAM Journal of International Security Assistance Management*, Richard Kwatnoski, Spring 1989.

14. "DSMC Launches New Workshop in International Acquisition Management," *National Defense*, April 1990.

15. "Preparing the New Global Manager," *Training and Development Journal*, Madelyn R. Callahan, March 1989.

16. "Why Aren't American Firms Training for Global Participation?" *Management Development Report*, Marcia Kirkpatrick, editor, Summer 1990.

17. "The Making of a Global Manager," *North America International Business*, Patricia M. Carey, June 1990.

18. The term "acquisition" in the defense department refers to the research, development and procurement of defense systems. Acquisition personnel are therefore analogous to business personnel in the private sector.

LOGISTICS INTERFACE CONTROL SYSTEM (LICS)

Paul J. Skalny
Don A. Carey

Army logistics managers now have another tool to assist in making meaningful contributuions to weapon systems design. It is the Logistics Interface Control System (LICS).

The LICS is a systematic, structured approach enabling logistics engineers to make a valuable contribution to the design of a weapon system throughout the Army materiel acquisition process (MAP). It promotes communication between logistics and system design engineers early in a system's acquisition life, serves as a catalyst to improve the quality of the concurrent engineering disciplines, reinforces the logistics support analysis (LSA) process, and helps to control design and life-cycle costs (LCC) of a weapon system.

For years the logistics community has been promoting the concept of supportability. An opportunity to prove this concept was provided to logistics engineers 2 years ago on a special streamlined weapon system prototype.

Mr. Skalny is a logistics management specialist, Research Development and Engineering Center, United States Army Tank-Automotive Command (TACOM). He is the logistics manager on a Defense Advanced Research Projects Agency (DARPA) program, and the TACOM ILS and MANPRINT point-of-contact for Line-of-Sight Antitank (LOSAT) weapon system.

Mr. Carey is a principal research scientist with Battelle Memorial Institute. He is the senior logistics engineer on a system engineering technical assistance (SETA) contract to DARPA. Mr. Carey is a graduate of the Army Command and General Staff College.

There are Challenges

With every opportunity there are challenges, and this weapon system was no exception. For example, the major challenges were: No predecessors; it was in the proof-of-principle phase with no integrated logistics support (ILS), MANPRINT or reliability, availability, maintainability (RAM) requirements identified in the contract; and, it involved multiple contractors. The LICS was created to meet these challenges and to take advantage of this opportunity.

The LICS was devised to: (1) generate and interact between the logistics and system design engineers, thereby influencing design of the weapon system; and (2) streamline the contract documentation requirements as prescribed by Department of Defense Directive (DODD) 5000.43, Acquisition Streamlining. With this in mind, the following LICS objectives were developed:

—Identify RAM, MANPRINT, supportability and accessibility issues/concerns

—Identify system design high-risk subsystems/components

—Establish a data base to store, retrieve, update and track issues/ concerns

—Provide an audit trail for the ILS/MANPRINT/RAM effort throughout the streamlined acquisition process

—Provide the project manager/ deputy project manager (PM/DPM) timely logistics information when responding to senior managers and congressional inquiries

—Assist PM/DPM in making decisions relating to technical performance, schedule, and funding.

Figure 1 illustrates methodology used to generate an interaction between logistics and system design engineers.

First, program documents like the operational and organizational plan, mission needs statement, and joint service operational requirement are reviewed to determine the operational concept and to ascertain whether the technology for the system is evolutionary or revolutionary. Next, the contractor's technical proposal is analyzed to identify the different types of equipment and subsystems proposed in the design of the weapon system. "Top level" evaluation of the proposed weapon system configuration (system/subsystems) is then performed by a small, diverse team (3-5 people) of experienced logistics and system design engineers.

The 12 ILS elements shown in Table 1, along with RAM, supportability, accessibility, human factors, safety and health hazard considerations, are used as a guide during evaluation to derive specific ILS/MANPRINT/RAM issues for each subsystem/component comprising the weapon system.

The issues for the weapon system are developed by:

—Examining the program documents to determine operational mission requirements for the weapon system

— Analyzing the contractor's winning technical proposal that describes in detail (diagrams, figures and tables) how the weapon system will be designed to accomplish the operational mission requirements.

Some typical issues might be: Are special tools and test equipment required to support this equipment at each maintenance level? Are there any special or unique packaging, handling and storage requirements? Are special support (maintenance/ training) facilities required? Is the equipment accessible for repair?

The initial list of issues is then provided to the prime contractor's ILS manager in both paper and floppy-disk media. Shortly thereafter, a joint government/contractor working group meeting is held. Participants in this group parallel the usual make-up of the ILS management team (ILSMT). Each issue derived from the "top-level" evaluation is reviewed/revised and quantitatively scored and ranked by the working group as either high, medium or low-risk and as either high, medium or low criticality. The total risk is a simple multiplicative of criticality and risk as shown in Table 2.

With the total number of issues identified for each criticality and risk category, the LICS data sheets (Figure 2) are completed and entered in the data base for storage, retrieval, updating and tracking.

A Word of Caution

As you can see, the information required on the LICS data sheet is straightforward; however, a word of caution is in order. It is strongly

TABLE 1. ILS ELEMENTS

(1) DESIGN INFLUENCE
(2) MAINTENANCE PLAN
(3) MANPOWER AND PERSONNEL
(4) SUPPLY SUPPORT
(5) SUPPORT EQUIPMENT AND TEST, MEASUREMENTS, AND DIAGNOSTIC EQUIPMENT (TMDE)
(6) TRAINING AND TRAINING DEVICES
(7) TECHNICAL DATA
(8) COMPUTER RESOURCES SUPPORT
(9) PACKAGING, HANDLING, AND STORAGE
(10) TRANSPORTATION AND TRANSPORTABILITY
(11) FACILITIES
(12) STANDARDIZATION AND INTEROPERABILITY

SOURCE: AR 700-127

TABLE 2. CRITICALITY AND HIGH-RISK WEIGHTING CRITERIA

CRITICALITY (O&O)

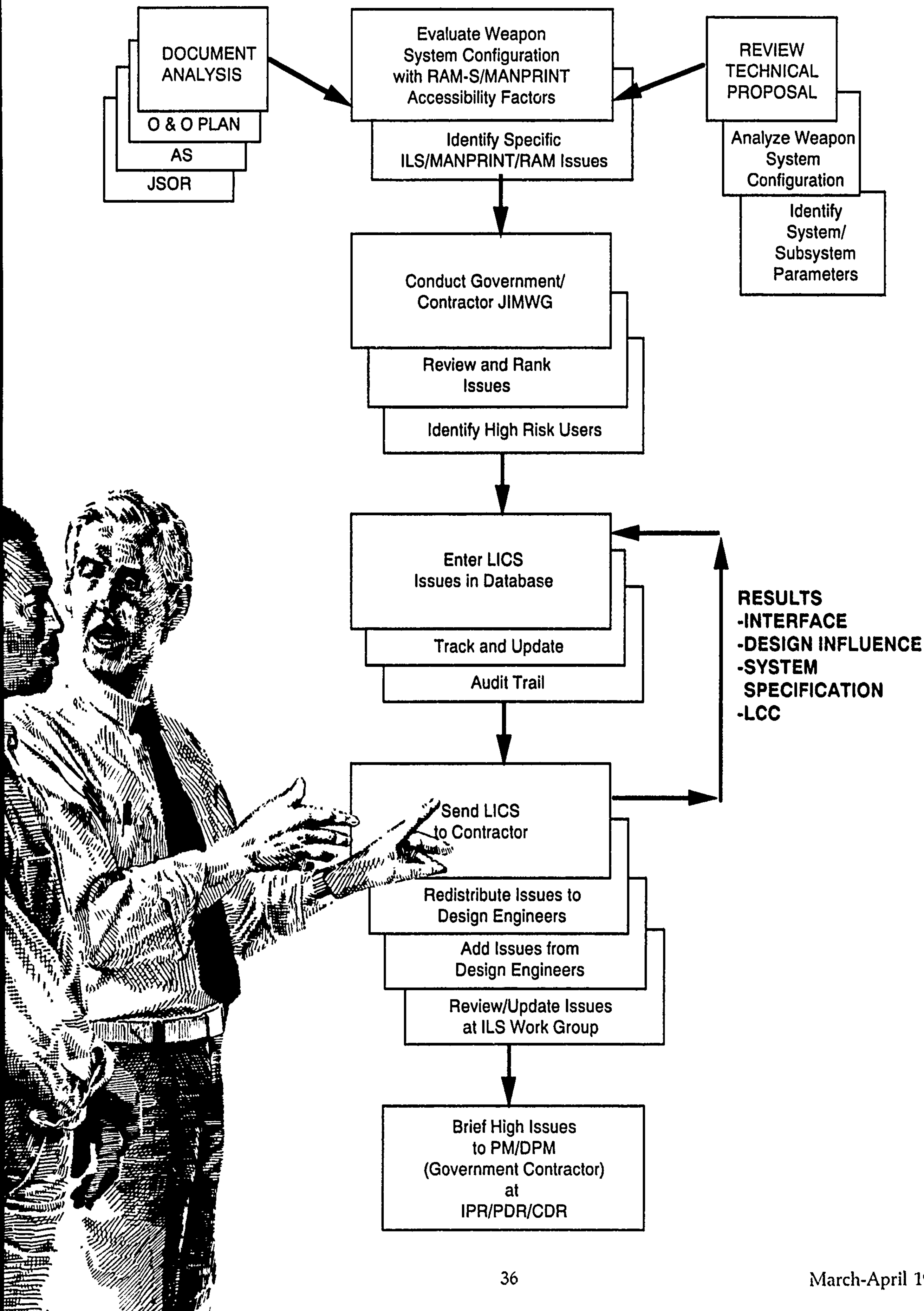
(3) HIGH - SIGNIFICANTLY IMPACTS OPERATIONAL MISSION
(2) MODERATE - MODERATELY IMPACTS OPERATIONAL MISSION
(1) LOW - MINIMAL IMPACT ON OPERATIONAL MISSION

RISK (RAM-S/MANPRINT & ACCESSIBILITY)

(5) HIGH - SIGNIFICANTLY IMPACTS WITH NO SOLUTION IDENTIFIED
(3) MEDIUM - SIGNIFICANT/MINOR IMPACTS WITH SOLUTION OR WORKAROUND IDENTIFIED
(1) LOW - NO IMPACT/NO PROBLEM IDENTIFIED

TOTAL RISK=(CRITICALITY x RISK)

FIGURE 1. LICS METHODOLOGY



LICS REPORT/WORKSHEET

DATE:

LIC NO.:

ITEM:

SUBSYSTEM CRITICALITY: ISSUE RISK: TOTAL RISK:

ISSUE IDENTIFIED: DATE IDENTIFIED:

ACTION:

RESPONSIBLE ORGANIZATION/POC:

PHONE:

SUSPENSE:

RESOLUTION:

FIGURE 2

recommended that a qualified engineer provide the final review and actually input the issues into the data base. A qualified engineer should review contractor updates before information is entered in the data base.

Perhaps the key to the LICS methodology is the continued coordination of issues with the contractor. The contractor's ILS manager is tasked to take the LICS issues and redistribute them to the appropriate weapon system design engineers for resolution; add issues recommended by the design engineers; provide in process reviews (IPRs), preliminary design reviews (PDRs) and critical design reviews during ILSMT meetings. The status of the high criticality/risk items are briefed to government and contractor PMs at all the reviews. Ultimately, identified issues are incorporated into the system specification.

Using LICS allows for documentation requirements to be streamlined. The contractor's explanation on how and by whom the issues will be resolved provides the government comprehensive information on the contractor's organizational structure, logistics and system design engineer's responsibilities, and on subcontractors' interfaces. From this exchange of information, the government gains confidence in the contractor's capability to resolve the LICS issues. Consequently, logistics requirements become isolated for government and contractor. It is the knowledge that key information will be a result of the LICS, which subsequently allows the government to streamline the required contractual documentation.

The LICS is an example of concurrent engineering in action. Experience with the special streamlined prototype weapon system indicates that LICS is influencing the design and thereby the life-cycle cost. The LICS provides government and contractor ILS managers a data base to track issues and an audit trail for the ILS/MANPRINT/RAM concerns throughout the materiel acquisition process. More importantly, by implementing LICS, the PMs/DPMs have at their fingertips an automated near real-time management tool that gives emerging and existing design issues.

ANDREWS/ADLER

(Continued from page 17)

physically housed at the Electronic Systems Division, Hanscom AFB, Mass. The CGADS uses a checklist method of asking questions to suggest the applicable policies, contract clauses, tasks, and military standards to address in your SOW. The CGADS is a good development aid for providing references, but it does not provide good examples of SOW tasking statements. Further information can be obtained by contacting Mr. Fred Santino at AV 478-7575.

Other automated tools include Docwriter located at Space Division, Los Angeles AFB, Calif., and a Navy system known as systematic acquisition requirements tailoring and scheduling (SMARTS). Docwriter is supposedly reliable for those accessing it within the Los Angeles area, but may not perform as admirably when accessed by long-distance modem. The SMARTS was developed to tie together modularized acquisition documents, like the SOW and CDRL, and makes use of extensive cross-referencing. The SMARTS point-of-contact is Mr. Glen Coleman at (703) 602-7946.

Recommendations

Critical questions remain. Is the SOW as important as it has been made out to be? We think so.

Are current sources used to educate and aid in SOW development sufficiently detailed and reasonably available? We don't think so.

We feel our few recommendations are essential.

—Specific courses must be developed to teach SOW preparation to include basic technical writing skills; the legal implications of SOW organization and content; and the integrating skills needed to tie SOW requirements to other parts of the contract.

—Standardize SOW format and SOW preparation policies. There is entirely too much variety and too much confusion in SOW formats as they exist. The current MIL-HDBK-245B, with minor updating and improvements, could serve as the mandated baseline for SOW development.

—If a policy is not instituted to standardize SOW preparation, then as a minimum, the Data Requirements Review Board (DRRB) should be chartered formally to perform a final review of the SOW and CDRL for consistency and applicability before release of the formal solicitation. We believe that, collectively, people in the government do not challenge SOW requirements strongly enough. The program managers may be held ultimately accountable for SOW content, but they need the advise of a group of functional experts on the completeness and accuracy of the SOW. The DRRB would be the ideal group to do that. This recommendation is not our original idea. To the Army's credit, they use the DRRB in this fashion. The MIL-HDBK-245B encourages using the DRRB for reviewing SOW format and content. We merely are adding our support to the recommendation.

Summary

As this and our previous article have stated, we have many problems associated with SOW development. There are several documents available to help minimize these problems, like MIL-STD-881 on work breakdown structure and MIL-HDBK-245B on SOW preparation. There are software tools like CGADS, Docwriter and SMARTS to assist in SOW content. Unfortunately, it appears we are not aware they exist or we choose not to use them.

In either case, the result has been corroborated by our program manager survey that our SOWs, in general, are ineffective. We firmly believe that SOW standardization is a must, that more direct emphasis needs to be placed on an educational program for SOW development, and that a final structured group review of the SOW is needed before formal solicitation release.

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John Rittenhouse, Sr. Vice President, GE Aerospace; and Chair, Defense Science Board Acquisition Streamlining Task Force

Don Fuqua, President, Aerospace Industries Association of America, Inc.

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MG Lynn H. Stevens, Commandant, Defense Systems Management College (moderator)
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Viewpoints on PROGRAM MANAGEMENT SUCCESS

Virginia A. Lentz
David D. Acker

To counteract negative publicity about the management of defense system programs, this paper focuses on program success. We hope that, where appropriate, the factors contributing to success will be adopted by current and/or future program managers.

Are there key factors leading to successful programs? From today's perspective, it appears that planning for and adapting to change, and treating a program as a business enterprise, would rank high on any list. Accommodating changes during defense system design, development and manufacture requires an aggressive leadership team that remains in charge long enough to lead the program through critical phases. From the outset, government and industry managers on a program need an effective partnership.

With changes on the European scene and scrutiny on the defense budget, there will be fewer new program starts in the near future and an increasing need for technology insertion and functional enhancements in existing defense systems under development.

There is general agreement by those managing defense system programs that a program can be run effectively when there is teamwork and trust between government and industry. Recent legislation to further restrict communications between government and industry during the acquisition phases will tend to hinder the possibility of program success. It seems important to review techniques and methods used on well-run programs, emphasizing techniques leading to program success.

Ms. Lentz is Manager, Systems Engineering Process Department, Federal Sector Division, IBM, Bethesda, Md. Mr. Acker is Professor of Management at DSMC. They are active on the DSMC Alumni Association Board of Directors.

Success-Oriented Techniques and Methods

Here are success-oriented techniques and methods most good industry program managers use.

—They act with authority and lead the program team, but delegate some responsibilities to team members, holding them accountable for results.

—They know the facts or obtain them when needed, try to understand each new situation, maintain flexibility in resolving program issues, and learn to deal effectively with perceptions.

—They maintain a consensus and support members of the program team, avoiding adversarial relationships if possible.

—They maintain a strong tie and a good relationship with the government program sponsor.

—They maximize the capability of the defense system while striving to decrease complexity, cost and time to field.

—They strive for quality in the defense system and management of the program.

—They recognize the need for, and support field testing of the system under development.

The government program manager maintains a good relationship with the industry program management team by:

—Exercising reasonable program oversight

—Conveying trust in the industry team while maintaining a close relationship with what the team is accomplishing at the program level

—Developing a good understanding of the contractor's business base and approach to management

—Conducting periodic reviews of program status

—Responding appropriately to requests for help, advice or support from the industry team

—Taking steps necessary to ensure program stability

—Minimizing paperwork and reporting requirements to the extent possible.

In general, a good program manager:

—Fights the "right" battles

—Knows and accepts responsibility for developing people, their loyalty and interests, and a team spirit

—Is receptive to new ideas, recognizing productive ideas are apt to occur to the person looking for them

—Has ability to know when to depart from the normal and when to take risks

—Has a sense of humor to cushion bumps along the road

—Sees the good in subordinates and tries to develop their good qualities

—Manages his time.

Problems, frustrations and success criteria for defense programs appear to be the same whether a program involves a single service, joint services or an international team.

During the years, many major programs have become so complex that most prime contractors cannot meet all requirements without the support of an associate contractor or contractors, many subcontractors, and many suppliers across the country/world. Increasing regulations and paperwork, and the need for increased automation to stay competitive, are driving small companies and suppliers out of the business. This is increasing the dependence of American companies on foreign suppliers. This is lengthening the lead time required for production and increasing the government's cost of a defense program.

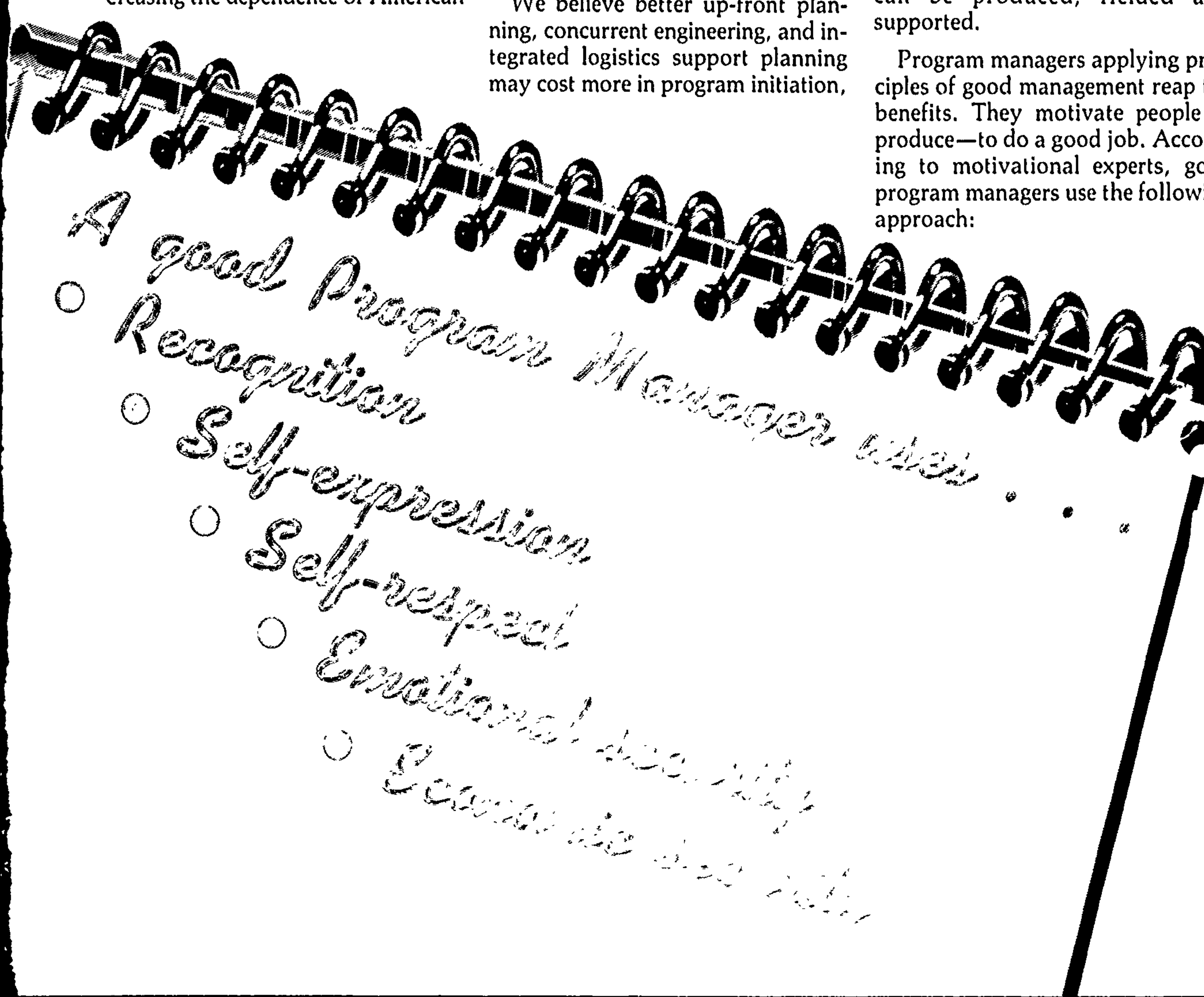
In the current unstable environment, where decisions by the Congress and Department of Defense management are almost unpredictable, the need for new and progressive leadership on defense programs is essential. The acquisition community needs to demonstrate it has the leadership capable of combating negative trends and maintaining the security of the United States in the face of declining defense budgets. Government/industry program teams need to approach cutbacks in a positive way and establish a "can do" attitude, while achieving the benefits of total quality management (TQM), concurrent (simultaneous) engineering, and computer-aided acquisition and logistics support (CALS).

Principles of Good Management

We believe better up-front planning, concurrent engineering, and integrated logistics support planning may cost more in program initiation, design and development; they offer significant payback during the production and support phases of a defense program. From program start, there needs to be an ongoing dialogue between the end-user and design/implementation contractor(s). There needs to be a sane budget process allowing industry to plan effectively for future activities. It is vital that the program manager have an effective engineering function responsible for achieving a technically "balanced" and economical system design. Such engineering responsibility will demand foresight in the creative and competitive application of technology to satisfy defense needs economically.

Except in the off-the-shelf or nondevelopment item (NDI) arena, there are requirements to be shared and technology capabilities and limitations to be considered. Sometimes the creative talents of hundreds of people need to be channeled to produce a prototype or engineering development model of a defense system that can be produced, fielded and supported.

Program managers applying principles of good management reap the benefits. They motivate people to produce—to do a good job. According to motivational experts, good program managers use the following approach:



—*Recognition*. Make sure program team members feel good work is appreciated, praised and awarded when appropriate.

—*Self-expression*. Give program team members the right to communicate ideas, suggestions, opinions and fears without concern of retribution. After all, we live in a democracy and no member of the program team should have to surrender his heritage when serving in a program office.

—*Self-respect*. Treat program team members as individuals and human beings—not statistics.

—*Emotional Security*. Make program team members feel their time and efforts will be rewarded fairly.

—*Economic Security*. Create a climate where program team members trust them and feel their jobs contribute to a worthwhile goal.

Successful program managers recognize how difficult it is to change themselves, and understand they have little chance of changing team members. Further, successful managers feel a responsibility for team members.

The essence of program management success is to set a long-range goal and relate daily work to it. Some program managers have only a vague idea of what they want to accomplish ultimately. Even when they do, some PMs do not know how to translate their desires into necessary short-range steps to ensure reaching the ultimate goal.

Point and Counterpoint

At the DSMC Alumni Association Symposium in the spring of 1990 during the point-counterpoint session, Dr. William N. Hunter asked participants Anthony Batista, consultant and former House Armed Services Committee Director, and Lawrence B. Lindsey, Special Assistant for Policy Development to the U.S. President, to describe program success; i.e., how the government can provide an environment where contractors successfully adopt creative and innovative ideas. The panel indicated there needs to be a framework of realistic goals and objectives on each defense program. Panel members also said the following.

The panel indicated there needs to be a framework of realistic goals and objectives on each defense program.

—The formal defense system planning process should be flexible. Progress is often slow from budget creation to budget execution.

—The plan on each program must readily accommodate change.

—More attention needs to be focused on manufacturing, a growing segment of our economy.

—National laboratories need to be structured to encourage more involvement by the private sector.

—The defense acquisition community needs to focus on cost reduction to weather problems occurring during the current downturn.

—Government and contractor acquisition executives need to be willing and able to work as partners in dealing with the Congress.

—Defense legislation is being written on the floor of the Congress and should be written in committee.

—When a program manager is called to Capitol Hill to address a congressional committee, he must give sufficient thought to what he has been doing or committee members will have a "field day" at his expense.

—The potential of the peace dividend should be viewed with caution. The United States must be ready to make a quick recovery if the peace dividend suddenly collapses.

Dr. William Hunter, Lawrence Lindsey and Anthony Batista discuss program success for DSMC alumni.

Program Management Education

The need for adequate preparation for program management should not be treated lightly or overlooked. The Defense Systems Management College (DSMC) is providing the necessary background and direction to prepare military service, Office of the Secretary of Defense, and industry personnel for effective management of programs. Demand for graduates of the DSMC Program Management Course and short courses will remain strong in the foreseeable future, even in an era of declining DOD resources.

Gregory T. Wierzbicki, DSMC Deputy Commandant and Provost, said there will be changes and continuing emphasis in the basic program of the College to satisfy its chartered role. Specifically, there will be the following.

—A return to two Program Management Course (PMC) classes per year beginning in 1991. There will be no overlap in these classes as was the case recently. This will provide more opportunity for faculty members to keep abreast of current management practices and to lead development of new methods.

—An increase from 630 PMC graduates in 1990 to 840 graduates by 1992. This will help satisfy projected needs of organizations sending personnel to the course.

—A continuing emphasis on acquisition management research and the assembly and dissemination of information concerning policies, methods and practices in defense acquisition management.

—A continuing development of software tools to be used as decision aids in College classrooms and provide management aids in program management offices for the military services.

...there will be changes and continuing emphasis in the basic program of the College to satisfy its chartered role.

—Gregory Wierzbicki
DSMC Provost

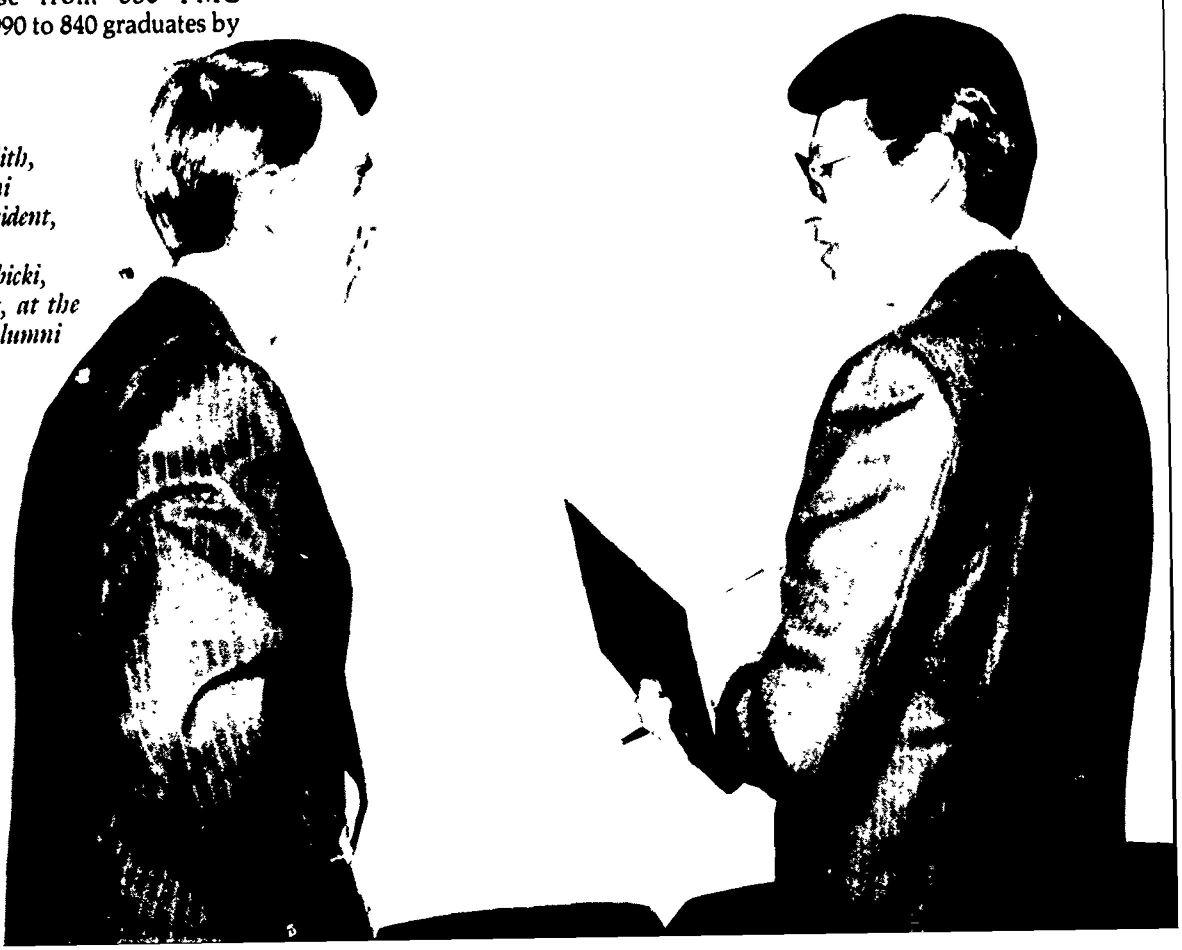
—A continuing focus on total quality management because it presents the challenge and opportunity for success in managing programs.

Looking outside the current program management community, there is a need for government and industry personnel to be more innovative by interesting students at the high-school level in science, engineering and mathematics. The future is in the hands of our youth, but we can help now to ensure our nation will survive and flourish in the future.

Final Thoughts

We would be wise to recognize that the art of leadership is to retain an adventurous spirit without going overboard. Successful program managers know this and practice it. Thomas Drier added another dimension by saying, "When you find a man who knows his job and is willing to take responsibility, keep out of his way and don't bother him with unnecessary supervision."

Surely the highest reward for a program manager's labor is not what he "gets for it," but what he "becomes by it."



Joseph Meredith, DSMC Alumni Association president, confers with Gregory Wierzbicki, DSMC Provost, at the Spring 1990 Alumni Symposium.

THE STRUCTURE OF AMERICAN INDUSTRY

Edited by Walter Adams
Published by Macmillan Publishing Company, New York
Collier Macmillan Publishers London
Eighth Edition 1990

This new editon edited by Walter Adams distinguished university professor of economics and past president of Michigan State University, recognizes that one major transformation in political economy since the first edition (published in 1950) is renewed awareness that power relationships in society are "a matter of profound social concern and require continuing confrontation by public policy-makers."

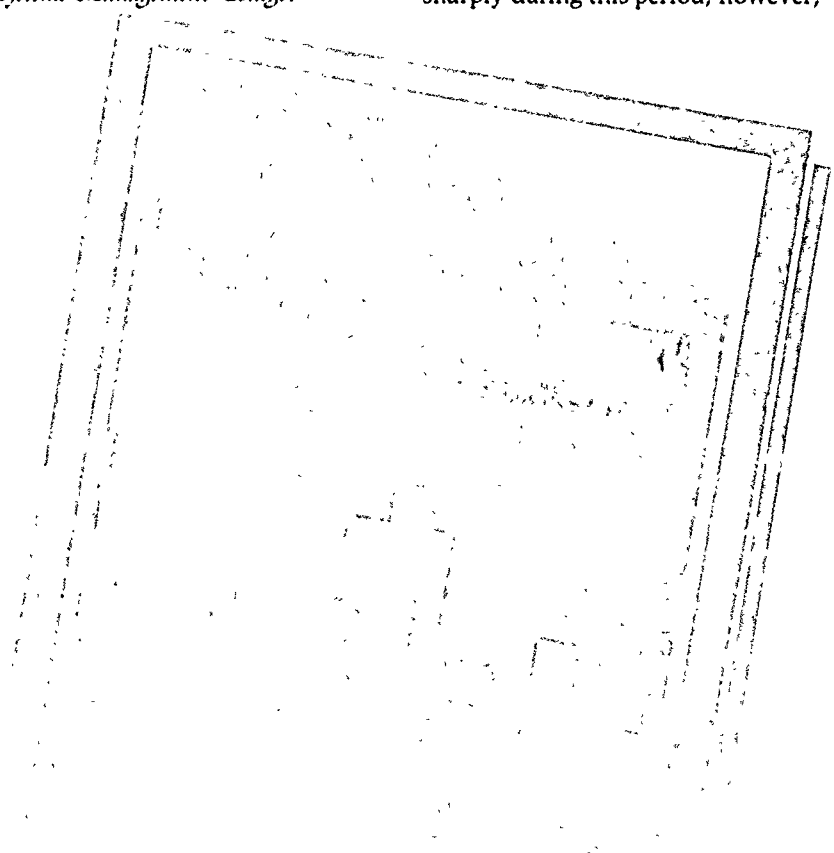
In *The Federalist*, No. 51, James Madison said, "A dependence on people is...the primary control on the government; but experience has taught mankind the necessity of auxiliary precautions...." These auxiliary precautions require a separation of power between different branches of government, and dispersion of power among the citizenry. Madison wrote that the underlying purpose of this arrangement is to prevent rulers from oppressing the ruled; and one segment of society from oppressing another. This distrust of concentrated power is relevant not only to political but to economic institutions. When economic power exists, it eventually may be used by those controlling it for whatever ends they choose.

There is a debate today about "the proper role of government, the virtues of megamergers and corporate giantism, the challenge of international competition, and the need to reindustrialize America." Therefore, the timing of this edition is excellent. It offers a discussion of various structural organizations, behavioral patterns and performance records. It places emphasis on international comparisons of industries, where they are relevant, in the European economic community and Japan. Because each industry is different, the book can serve as a "live" laboratory for clinical examination, comparative analysis, and the evaluation of public policy alternatives.

The book concentrates on 11 industries, including petroleum, steel, automobile, computer, and weapons. The book contains a chapter on conglomerates and a chapter on public policy in a free enterprise economy. Let's review these subjects as they are covered in the book.

David D. Acker, our reviewer, serves in the Research Directorate at the Defense Systems Management College.

The Petroleum Industry. This chapter was prepared by Stephen Martin, professor of economics at Michigan State University. Martin examined the economic and political forces that have determined the performance of the world oil market and the U.S. submarket. He indicated that from the mid-1950s through 1973, there was a transition from a market dominated by international major producers to a market dominated by the governments of oil-producing countries. From 1973 to 1986, crude oil production declined slightly in the United States and the trend has been continuing. Output from Western Europe has increased sharply during this period; however,



the North Sea oilfields probably will peak in the early 1900s and decline thereafter. The output in Latin America has risen since 1973 and the trend probably will continue. Crude oil output in the Third World, which includes China and less-developed countries in Africa, is expected to increase. Martin claims the entry of new oil-producing countries is undercutting the power of Oil Producing Export Countries (OPEC). The OPECs have reacted by seeking secure outlets for their oil.

The Steel Industry. Walter Adams, editor, and Hans Mueller, professor of economics and finance at Middle Tennessee State University, prepared this chapter. Until the 1960s "a handful of vertically integrated giants dominated the industry." Then, there was an invasion by domestic and foreign newcomers. The American steel industries pleaded for government protection, mostly in the form of trade restraints. By the 1980s, the steel oligopoly was moribund. There was a collection of helpless giants begging for government relief from a self-inflicted injury. Today, the American steel market is composed of about 10,000 distinct iron and steel products. These products are differentiated according to metallurgy, physical properties, and surface conditions. The term *market*, as used by the authors, connotes the interaction of buyers and sellers in a geographical trading area. In the United States, the structure of the steel market is currently an oligopoly dominated by large integrated companies. Adams and Mueller think it would be prudent to make competition "the lodestar of public policy regarding the steel industry."

The Automobile Industry. Walter Adams and James W. Brock, professor of economics at Miami University (Ohio), believe the automobile industry is one of the most concentrated oligopolies in the American economy. They divide the history of this industry into four distinct parts: (1) the era of independents; (2) the emergence of the Ford Motor Company as the dominant producer; (3) the shift of dominance to General Motors and progressive industry concentration; (4) the era of foreign competition. By the mid-1970s, the Big Three (General Motors, Ford, Chrysler), in collaboration with the United Auto Workers, made repeated efforts to obtain government protection from foreign competitiors. In the 1980s, the Big Three had to struggle to advance, both by product innovation and by new production technology.

"A dependence on people is...the primary control on the government; but experience has taught mankind the necessity of auxiliary precautions."
—James Madison

The Computer Industry. Gerald W. Brock, chief of the Common Carrier Bureau, Federal Communications Division, explains that the electronic digital computer was "born out of the critical military requirements for computation during World War II and the early cold war." The heavy military expenditures on computers by the United States made the early U.S. industry practically synonymous with the worldwide computer industry. The IBM, although not the first computer company, became the world's dominant computer company in the 1950s and has retained that position. According to Brock, the highly competitive minicomputer and microcomputer market segments, together with extensive competition from Japanese producers, are now reducing IBM's dominance of the worldwide data processing market.

The Weapons Industry. The weapons industry, according to William B. Barnett, vice president of Charles River Associates, and Frederic M. Scherer, professor of economics at Harvard University, is one of the largest and most fascinating branches of American industry. This industry includes aircraft, guided missiles, electronics, computers, communication systems, shipbuilding, and ordnance. It uses many of our nation's highly skilled scientific and technical human resources and they perform more than one-third of the research and development undertaken by all U.S. industries. Further, the weapons industry has sustained an extraordinary rapid pace of technological advance and it is characterized by unusually large uncertainties concerning product characteristics and costs. Because of these uncertainties and the large size of the individual defense and space programs, special institutions have been created to shift financial risks from the producers to the government. The government, in turn, has usurped many of the decision-making functions traditionally exercised by sellers. The authors believe that few things are more enduring than requests for reform of the system by which the United States acquires weapons. In their final analysis, Barnett and Scherer concluded that "the most important thing that can be done to improve the weapons acquisition process is to bring the qualitative arms race under control."

Conglomerates: A "Nonindustry." Willard F. Mueller, professor of economics and professor in the Law School, University of Wisconsin-Madison, explains that the large modern corporation typically is not confined to a single industry; rather, it embraces many lines of business, and its operations often extend over much of the world. The power a conglomerate has within a particular industry depends on its market position, not only in that industry but in all of its other lines of business at home and abroad. The trend toward centralization and conglomerate bigness is becoming greater because corporate decision-making is often centralized by numerous joint ventures among the large corporations.

(Continued on page 47)

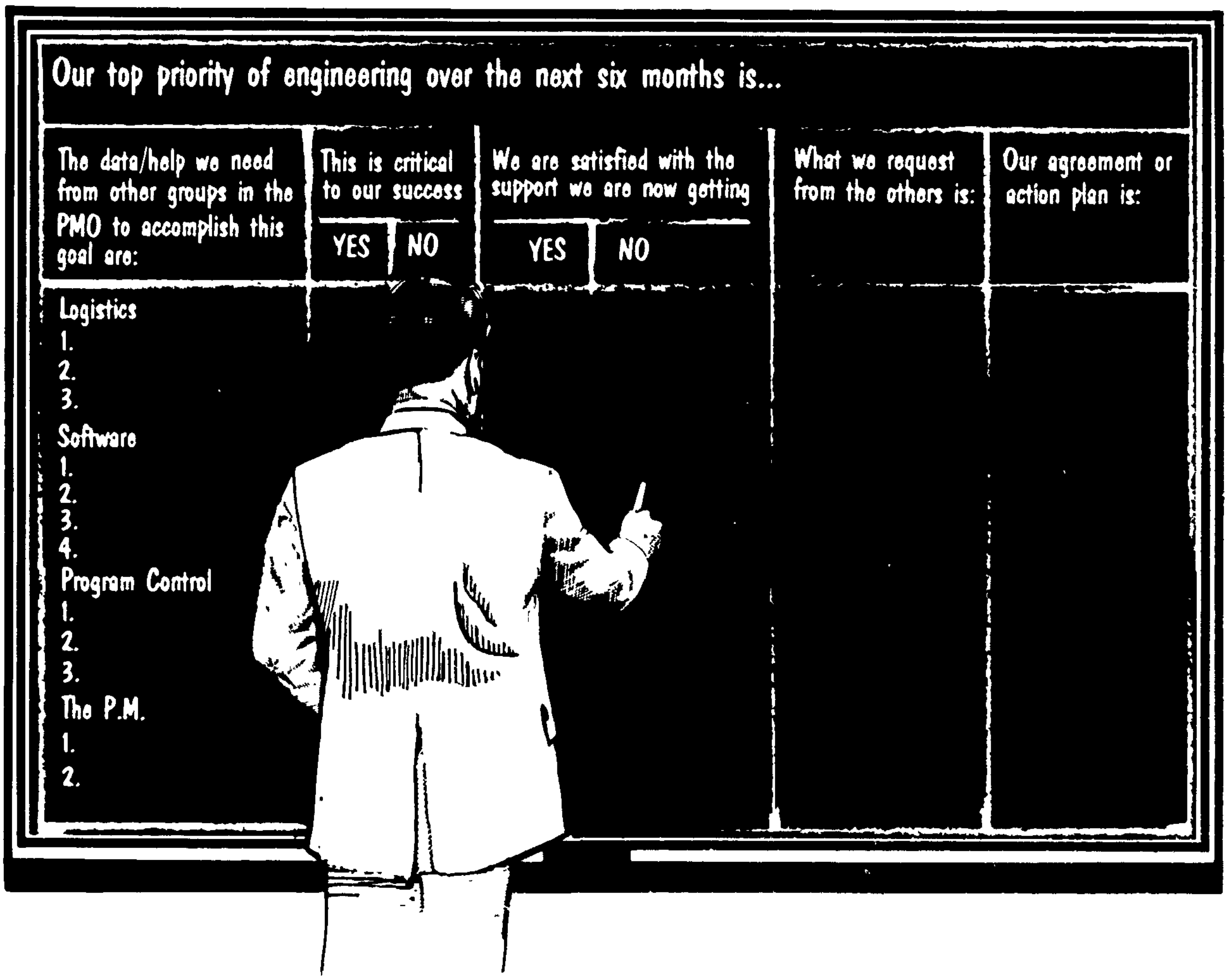
ORGANIZATIONAL INTEGRATION:

ne paradox every organization faces is that it must be divided into functional areas, differentiated, to deal effectively with its environment. Functional areas must be integrated if an organization is to meet customer expectations. Organizations operating with the matrix structure, like program management offices, must deal continually with this paradox.

Major Wilson is a Professor in the Policy Organization Management Department at the Defense Systems Management College.

Achieving the proper integration level is critical. In this article, I outline an effective model for a 1-day, offsite to allow your organization to determine and achieve the integration level needed.

A skilled consultant managing this process is usually necessary. It is important that steps outlined be followed to provide optimal results. First, I describe the process and then mention critical logistical considerations necessary to achieve a successful meeting. At first, functional PMO groups will work together, but separate from the other functional groups. When the former groups



finish individual work, they interact with each of the organization's *other* functional groups to share results.

STEP 1

Members of each group create a list of goals to accomplish in the next 6 months.

STEP 2

Each group prioritizes its list of goals.

STEP 3

Top priority will be written in a statement. A list is developed of inputs, coordination, information, etc., needed from the other functional areas to accomplish this priority goal. A list is developed for each of the *other* functional groups, including the PM as a separate "group."

STEP 4

Each group prioritizes its lists of inputs, coordination, etc.

What has been created to this point (see illustration) are prioritized data which must cross boundaries of functional groups if they are to accomplish listed goals.

STEP 5

Functional groups apply the following criteria to each list of its data for each other functional area.

—Is this critical to your team's effectiveness?

—Are you satisfied with the existing level of support?

—What request do you have for other groups?

—What agreements will you make with other groups to obtain needed data?

Each functional group will have developed a matrix similar to Figure 1.

STEP 6

Negotiate agreements with each of the other groups to obtain the cooperation needed to accomplish this specific objective, the group's top priority. This is accomplished in a round-robin manner, functional groups paired. An alternative is for groups to gather together, one at a time, and for the entire organization to be briefed on the output of each group, one at a time. This accomplishes a briefing for the entire organization, shows amount of integration needed, brings all personnel up-to-date on major goals of all the functional areas, and gives an opportunity for whole-group interaction regarding goals.

The level of interdependence required in the organization is indicated by length of the lists. Longer lists indicate a need for a high level of interdependence and, therefore, a high level of integration among functional groups.

This design has at least three subtle aspects which participants and consultants need to know. First, the design will produce *a lot* of data. Lists generated by each functional group will be long. To capture this data effectively matrixes should be prepared ahead of time for each functional group. Groups should not use abbreviations or cryptic language. Outsiders should be able to understand *all* information.

Second, administrative support is needed. Functional groups will be busy and will not have time to transfer data to a medium to take back to the office; therefore, take personnel to record results and who can be utilized.

Third, offsite meeting facilities are important. This model works best when each functional group has a separate room and the walls of that room can be covered with paper to make a large writing/working area.

In 1 day, functional groups will be able to negotiate only the top 1-2 goals.

The design presented herein should allow a program manager to determine the level of integration necessary among PMO functional groups. Additional benefits might be effective teambuilding such as including new members, and bringing other members up-to-date on organizational efforts.

If you are interested in discussing applicability of this design, please contact me: Major Jim Wilson, Defense Systems Management College, SE-P, Fort Belvoir, VA 22060-5426; Commercial telephone (703)664-3990, or Autovon (354)3990.

BOOK REVIEW

(Continued from page 45)

The author believes there is evidence that vast conglomerate mergers have increasingly centralized the economy and transformed our economic-political order. Proposals to restrain conglomerate mergers, according to Mueller, have received scant support in recent years.

Public Policy in a Free Enterprise Economy. Walter Adams identifies objections to monopoly and trade restraints: (1) monopoly affords little consumer protection against exorbitant prices; (2) monopoly causes a restriction of economic opportunity and a misallocation of productive resources; (3) monopoly often restrains technological advances and, thus, impedes economic progress; (4) monopoly tends to impede the effectiveness of stabilization measures and to distort their structural impact on economy; (5) monopoly threatens not only the existence of a free economy, but the chances of survival of free political institutions. Adams says the Sherman Act of 1890 sought to preserve competitive free enterprise by imposing legal prohibitions on monopoly and free·restraint of trade. It was directed against existing monopolies and existing trade restraints. Enforcement authorities were not able to cope with practices used to effectuate unlawful results and they could not attack the growth of monopoly. Adams believes that industrial giantism cannot be ignored because "it breeds an arrogance of power and tends to divert entrepreneurship from risk-taking, investment, research and development, productivity enhancement and market expansion into efforts to manipulate the state for protectionist ends." Thomas Jefferson and our founding fathers believed that "it is not by the consolidation of powers, but by their distribution, that good government is affected." This proposition is applicable to the organizational structure of economic and political institutions.

The book is well written and thought-provoking. Data appear to be carefully researched and findings will be of special interest to economic and business-minded students.

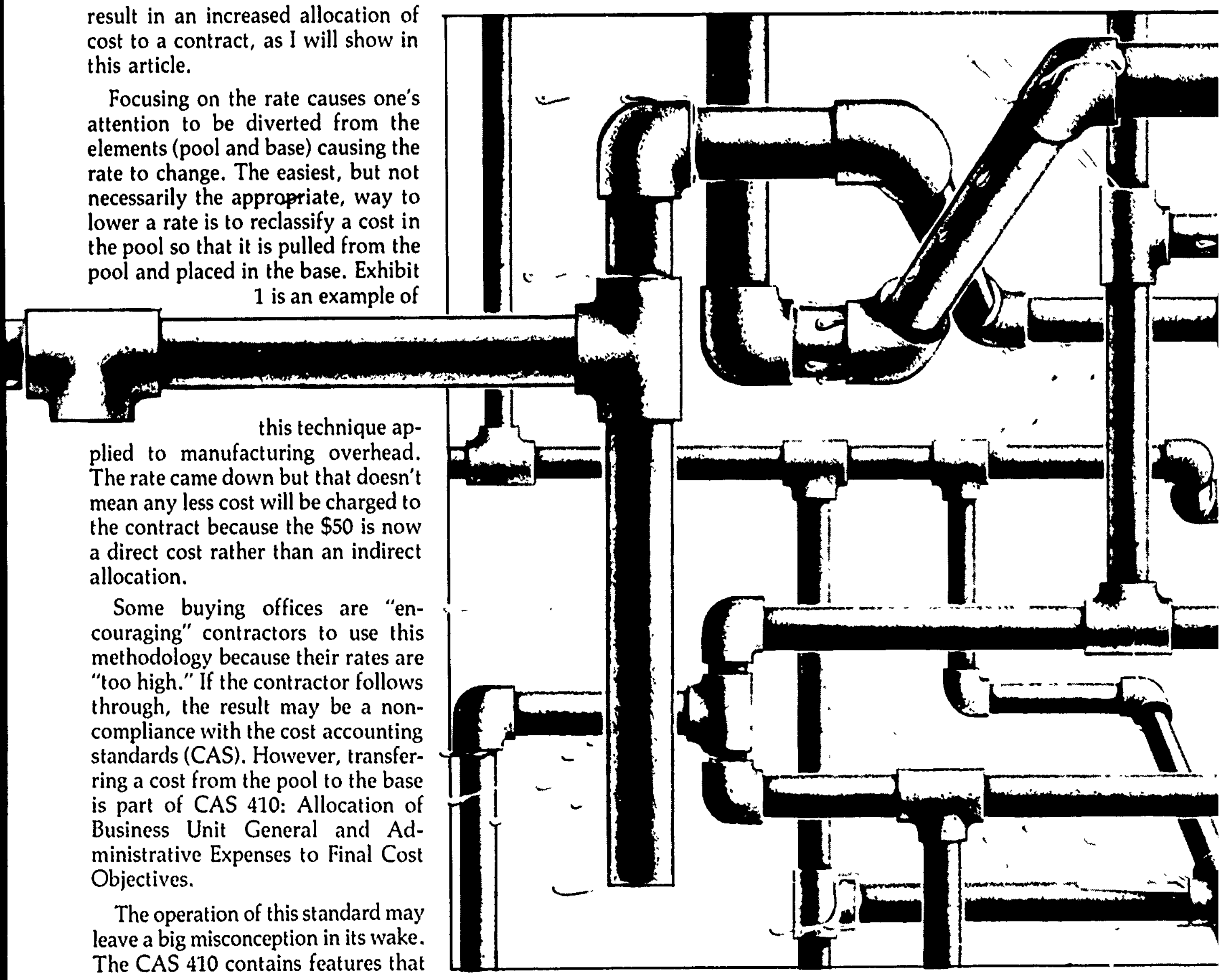
GENERAL & ADMINISTRATIVE

Lower Rates Do Not Mean Lower Costs

David A. Sommer

There seems to be renewed effort in obtaining lower rates for contracts. There is a misconception that a lower rate will result in lower total contract costs. There are instances where a lower rate can result in an increased allocation of cost to a contract, as I will show in this article.

Focusing on the rate causes one's attention to be diverted from the elements (pool and base) causing the rate to change. The easiest, but not necessarily the appropriate, way to lower a rate is to reclassify a cost in the pool so that it is pulled from the pool and placed in the base. Exhibit 1 is an example of this technique applied to manufacturing overhead. The rate came down but that doesn't mean any less cost will be charged to the contract because the $50 is now a direct cost rather than an indirect allocation.



Some buying offices are "encouraging" contractors to use this methodology because their rates are "too high." If the contractor follows through, the result may be a noncompliance with the cost accounting standards (CAS). However, transferring a cost from the pool to the base is part of CAS 410: Allocation of Business Unit General and Administrative Expenses to Final Cost Objectives.

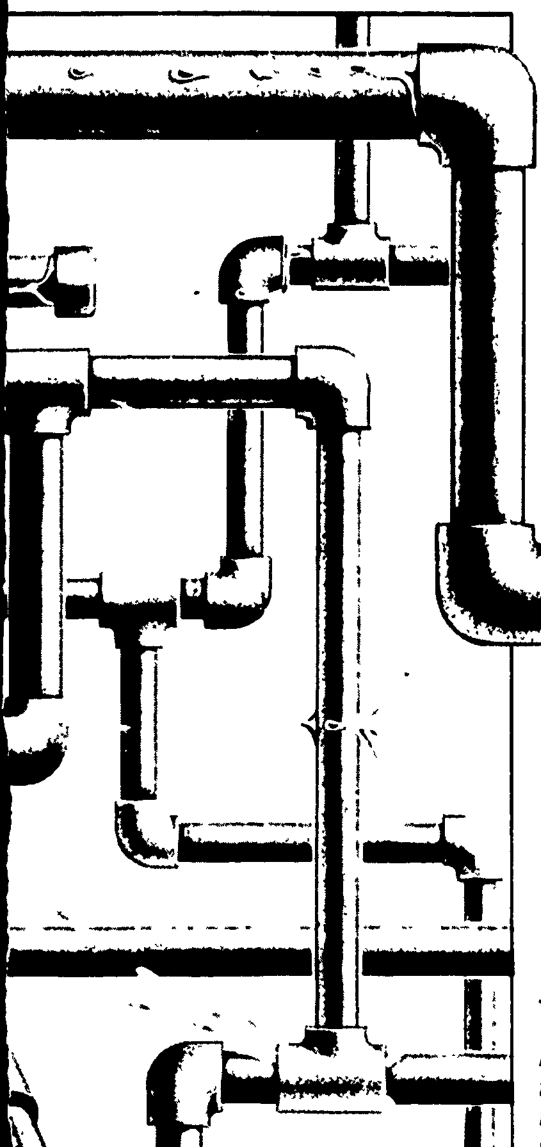
The operation of this standard may leave a big misconception in its wake. The CAS 410 contains features that will "purify" the general and administrative (G&A) expense pool, causing it to decrease. Some, if not all, of these costs may be included in the G&A allocation base. The decreased pool and increased base will work together to reduce the G&A rate, thereby creating the false impression that total contract costs also will be lower.

EXHIBIT 1. RECLASSIFY AND TRANSFER

$$\frac{\text{POOL}}{\text{BASE}} = \frac{\text{Manufacturing Overhead}}{\text{Direct Labor Dollars}} \quad \frac{\$200}{\$100} = 200\% \quad \text{Overhead Rate}$$

$$\frac{\$200}{\$100} \quad \xrightarrow{\text{Reclassify \$50 of Indirect Labor}} \quad \xleftarrow{\text{as Direct Labor}} \quad \frac{\$150}{\$150} = \$100\% \quad \text{Overhead Rate}$$

The intent of this article is to dispel the myth that a lower rate means lower costs. The G&A pool and the allocation base will be examined from the viewpoint of increasing objectivity in the allocation of G&A to contracts. The means to achieve greater objectivity is responsible in part for creation of the myth, which is perpetuated by a misconception of the CAS purpose.



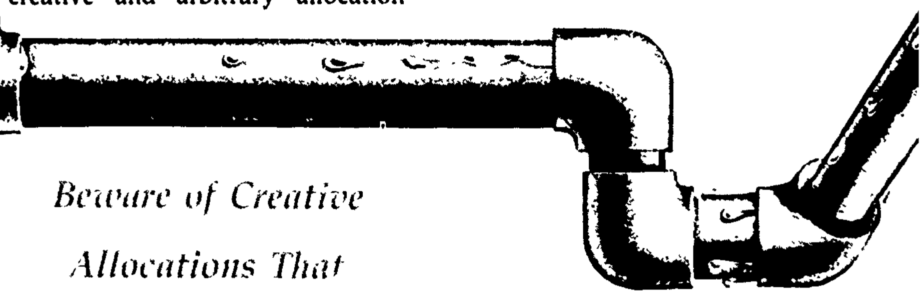
Purification of G&A: The Myth Begins

Before examining provisions of any cost accounting standard, the CAS purpose needs clarification. Many people believe standards were written to reduce the cost of government contracts. Decreased costs *may* result from applying the standards but this was not the focus of the Cost Accounting Standards Board (CASB). Its main concern was the equitable allocation of costs through consistent application of standards designed to increase objectivity. One of the biggest problem areas was allocation of G&A to contracts.

Traditionally, G&A has been viewed as a period cost that means it does not become part of the cost and a product/contract. However, government contract cost accounting uses full absorption costing, which means that G&A will be allocated to government contracts. How do you accomplish this when accounting literature doesn't address it? Thus, the door was open for subjective, creative and arbitrary allocation techniques because G&A, by its nature, is not easily allocated since it is "related" to all costs.

The title "general and administrative" indicates the type of costs that might be found in this category. If a cost was not related to some other indirect cost pool like manufacturing overhead, engineering overhead, material overhead, etc., it was thrown into the G&A pool. Eventually, that pool became a collection of costs not meriting the effort to determine individual allocation bases. Thus, G&A was viewed as a catchall of general costs.

The first step to bring order out of chaos is providing a definition of the costs that can be classified appropriately as G&A. The CAS 410 states G&A includes expense for the general management and administration of the business unit as a whole. This narrow definition is the first step toward "purifying" the G&A pool and also is the beginning of the myth; i.e., lower rate means lower costs.



Beware of Creative Allocations That Can Lead to False Reductions

Mr. Sourwine is a certified cost analyst, has been an auditor with the Defense Contract Audit Agency and is a member of the American Society of Military Comptrollers.

Excluding costs from the G&A pool does not mean these costs are unallowable. One provision of CAS 410 is that costs are not properly classified as G&A if they can be allocated by a base better than cost input. Examples are selling expenses, personnel department, purchasing and data processing. Each can become a separate indirect cost pool to be allocated by a more appropriate base as shown in Table 1.

TABLE 1. ILLUSTRATIVE ALLOCATION BASES

COST	ILLUSTRATIVE ALLOCATION BASES
Selling Expenses	Sales; Cost of Sales
Personnel Dept	Headcount; Payroll Dollars
Purchasing	Purchase Order; Value of Material
Data Processing	Machine Time

Pulling these costs out of the G&A pool will reduce the G&A rate but doesn't mean total contract costs will be lower. These costs will be allocated to contracts by a more appropriate base as shown in Exhibit 2. Greater objectivity has been achieved where little or none existed before the standard.

Reduction of the G&A pool also was aided by the revised Department of Defense (DOD) weighted guidelines for determining profit. The G&A is no longer part of costs used for profit calculation. This resulted in contractors reclassifying previous G&A costs and putting them in other indirect cost pools as shown in Exhibit 3. This perpetuated the myth that total contract costs must be decreasing because the G&A pool and rate are decreasing.

One example of this reclassification and cost transfer involves the purchasing department. One contractor said that purchasing supported only manufacturing and moved the cost to the manufacturing overhead pool. In another case, a contractor pulled the cost of the accounts payable function out of G&A and transferred it to the material overhead pool because most of the effort involved processing and paying material invoices.

A closer examination of Exhibit 3 shows another part of the deception of the lower rate—the allocation base increased. Again, one provision of CAS 410 causes this. Costs excluded from the G&A pool as a result of one of the provisions of CAS 410 will be part of the cost input base if they are not allocated using the same base as G&A.

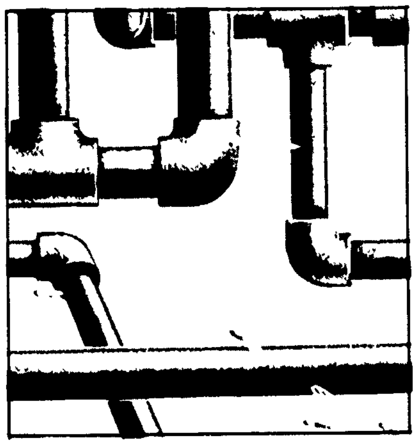
The Myth Is Compounded

Before promulgation of CAS 410 there was nothing specific concerning the base used to allocate G&A. Accordingly, almost anything was acceptable. Two popular bases were sales, or cost of sales, and direct labor. Exhibit 4 shows how costs can be misallocated by using a cost-of-sales base. This misallocation is caused by holding costs in the work-in-process account for fixed-price contracts. Thus, the current-period G&A will be allocated to cost contracts. When costs of fixed price contracts are released from the Work in Process account in the next cost accounting period they will pick up their share of that period's G&A. The result is a mismatching of G&A to the contracts for which it was incurred.

To avoid this mismatching problem, CAS 410 specified the appropriate base was cost input, not cost of sales. The standard provides three forms of cost input; total cost input, value added, and single element. The appropriate base is the one best representing the total activity of a *typical* cost-accounting period. Selection of a base is where the intent of CAS was miscontrued.

Those thinking CAS was intended to result in the least cost to the government would select the base causing the lowest allocation of G&A to government contracts. Evidence of this can be found in the General Dynamics Convair Division case (ASBCA 22461). In his decision, the judge said that inequity does not arise because the system caused decreased costs one year and increased costs the next.

Inequity in CAS means there is disparity between cost allocated and benefit received. This is why there are



To achieve a true reduction of contract costs, attention must be diverted from the rate to components of the rate

EXHIBIT 2. PULLED G&A

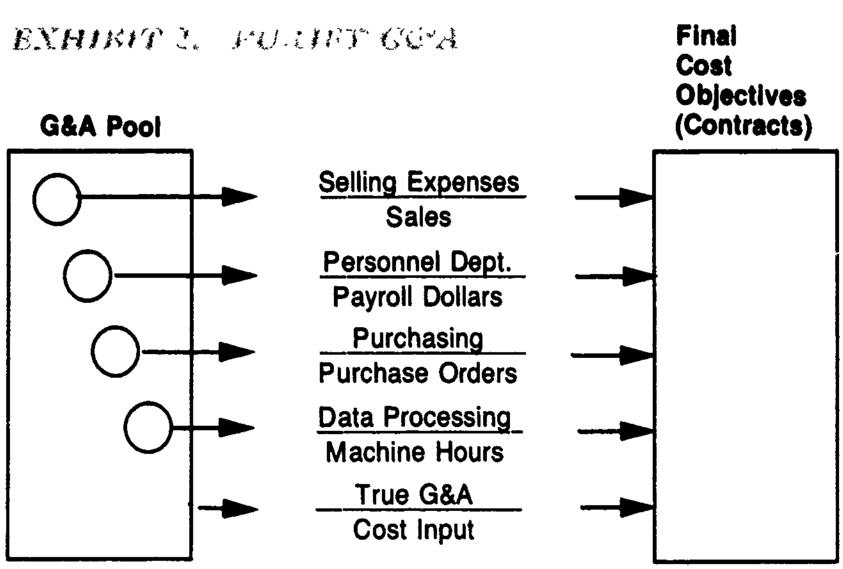
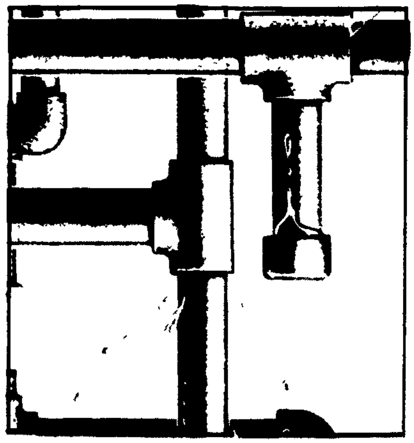


EXHIBIT 3. INCREASED OBJECTIVITY VS. REDUCED COSTS

	Before	Reclassify/ Transfer	After
Material	$100		$100
Labor	100		100
Mfg. O/H	100	20	120
Engr. O/H	100	10	110
Mat. O/H	100	10	110
G&A	100	50	50
IR&D	100		100
Selling Expense	0	10	10
Total Costs	$700		$700

$\frac{G\&A}{TCI} = \frac{\$100}{\$500} = 20\%$ $\qquad\qquad \frac{\$50}{\$550} = 11\%$

TCI = Total Cost Input = All costs not in the G&A pool except IR&D and B&P.



True reductions can be obtained through an analysis (cost/benefit, value analysis, etc.) of the individual costs in the expense pool.

three bases available under CAS 410, each eliminating costs that may be causing a disproportionate allocation of G&A.

Total cost input (TCI) is all costs not in the G&A pool except independent research and development (IR&D) and bid and proposal (B&P) costs. Value added (VA) is TCI less material *and* subcontracting. The single element base with the widest use is direct labor. One of these bases is the best representation of total activity in a *typical* cost accounting period.

By definition, the TCI and VA bases will include costs eliminated from the G&A expense pool except for G&A unallowable costs. Increasing the base lowers the rate, thereby compounding the myth this results in lower costs. The myth is compounded further by eliminating costs from the bases.

The VA and direct labor bases eliminate some costs from the base, thereby causing the base to be lower and the G&A rate to be higher. Exhibit 5 demonstrates the fallacy of the myth, "lower rates mean lower costs," or the converse, "higher rates mean higher costs." Look at Contract C. Going from TCI to DL, the G&A rate increased but costs allocated to C decreased. Although the myth is supported by Contracts A and B, it doesn't operate in all cases. Thus, the myth is more a fallacy than it is a truism. Total G&A didn't change. The allocation was rearranged.

Caveat Emptor

The buyer must be aware of false decreases achieved by way of creative allocation techniques. Lowering the rate doesn't mean an automatic

EXHIBIT 4. G&A ALLOCATION: COST INPUT VS. COST OF SALES

	A	B	Total
Beginning Work in Process	$ 10M	0	$ 10M
Cost Input (M, L, O/H)	$ 70M	$ 30M	$100M
Ending Work in Process	$ 60M	0	$ 60M
Cost of Sales*	$ 20M	$ 30M	$ 50M
G&A to be Allocated			$ 10M
G&A Rate			
Cost Input			10%
Cost of Sales			20%
G&A Allocation			
Cost Input	$ 7M	$ 3M	$ 10M
Cost of Sales	$ 4M	$ 6M	$ 10M

* Assumes all goods manufactured are sold.

EXHIBIT 5. G&A ALLOCATION

Contracts

Given:	Total	A	B	C
Material	$500	$100	$100	$300
Subcontracts	400	0	200	200
Direct Labor	300	120	120	60
Overhead	800	280	280	240
Total	$2000	$500	$700	$800
G&A	$200			
GFM*	$200	$200		

*Government Furnished Material

G&A Allocation:

		A	B	C	Total
TCI	$\frac{\$200}{\$2000} = 10\%$	$50	$70	$80	$200
VA	$\frac{\$200}{\$1100} = 18.2\%$	$73	$73	$54	$200
DL	$\frac{\$200}{\$300} = 66.7\%$	$80	$80	$40	$200

reduction of total contract costs. What it does mean is that there will be a change in the allocation arrangement. Looking again at Exhibit 5 and going from VA to TCI, the rate goes down because the base increased. This resulted in a shift of costs from Contracts A and B to C (A = -23, B = -3, C = +26). This shift is commonly made from fixed price contracts to cost reimbursement contracts.

To achieve a true reduction of contract costs, attention must be diverted from the rate to components of the rate. True reductions can be obtained through an analysis (cost/benefit, value analysis, etc.) of the individual costs in the expense pool. If a true reduction is to take place, a cost must be eliminated entirely and not shifted to another pool.

Another alternative to lowering total contract costs is to limit the amount of G&A the government is willing to pay, but this has its pitfall. The contractor now has an incentive to reclassify some G&A costs and transfer them to another pool to achieve the limit.

Modern Day "Forage" For Iron Horses

In the midst of the massive deployment to Saudi Arabia, in October, the Congress and the Administration allowed the Defense Production Act to expire.

This Act, a product of the Korean Conflict, provided *inter alia* the authorities for priority allocations for the military of materials and fuels should such be required in national emergency situations. An unknown bureaucrat remembered that the Civil War "Feed and Forage Act of 1862" *remained on the books.*

Thus, authority for priority allocation of fuel for military needs rests on the determination that petrofuels are the modern forage for our "iron horses."